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J. F. KELLY, *Editor*

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PROGRAM

WEDNESDAY **JANUARY 21**

"Theory and Practical Application of Atmosphere Control of Electric Furnaces" by A. N. Otis, General Electric Company, Schenectady, New York.

"The Electric Furnace as a Metallurgical Tool," by Charles McKnight, In Charge Alloy Steel Development, International Nickel Co., New York, N. Y.

"Resistance Welding" by Grover A. Hughes, Electrical Engineer, Truscon Steel Co., Youngtown, Ohio.

"The Manufacture of Acid Electric Steel and Cast Iron" by H. H. Walther, Director of Research, The Dayton Steel Foundry Co., Dayton, Ohio.

"The Coreless Induction Furnace in the Steel Industry," by Dr. E. F. Northrup, Vice President, Ajax Electrothermic Corporation, Trenton, New Jersey.

"Use of Electricity in the Manufacture of Tool Steels."

"Magnetic Analysis of Steels," by Lewis S. Reid, Chief Engineer, Magnetic Analysis Corp., Long Island City, N. Y.; followed by demonstration of the Oscillograph.

THURSDAY **JANUARY 22**

Welding Symposium—Following formal papers.

"Dynamic Properties of Welded Joints," by Charles H. Jennings, Research Engineer, Westinghouse Research Laboratories, East Pittsburgh, Pa.

"The Manufacture of Welding Wire," by George S. Rose, American Steel & Wire Company, New York, N. Y.

"Copper-Alloy Welding Rods," by I. T. Hook, Research Engineer, American Brass Company, Waterbury, Conn.

"Special Alloy Electrodes for Maximum Strength and Ductility," by Alexander Churchward, Consulting Engineer, Wilson Welder & Metals Co., North Bergen, N. J.

"Welding Rods," Wheeling Steel Corporation, Wheeling, W. Va.

I. Lamont Hughes, President of Carnegie Steel Company, Pittsburgh, Pa., is one of the foremost leaders of the Safety Movement in the Iron and Steel Industry. He has seen millions of dollars spent in the Industry to decrease the hazards of steel making, since his first connection at the Edgar Thomson plant at Braddock, Pa.

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The Constant-air-weight Method of Cupola Blowing

PART I

THE FUNDAMENTAL REQUIREMENTS OF IRON MELTING IN CUPOLAS

By H. V. CRAWFORD
Industrial Department, General Electric Company
Reprinted from the General Electric Review.

The method of supplying cupola air by weight instead of by volume is almost revolutionary, though so logical that the wonder is that it has not always been in use. Mr. Crawford, who received in 1929 a Charles A. Coffin Award for developing the method, here outlines cupola operation; later the electrical equipment, whereby the proper weight of air is automatically supplied, will be described.

—EDITOR

FOR a great many years cupolas have been operated either on the basis of holding a constant wind box pressure or of supplying a constant volume of air. The new method involves the supplying of a constant weight of air. The logic is very simple: The air is used to support combustion in the cupola, which is the union of the carbon of the fuel with the oxygen of the air. These substances combine to form gases always in proportion to their atomic weights, or total actual weights by atoms, pounds or tons. The air and the fuel should, therefore, be supplied by weight, just as in most cases the coke is charged; but previous to the introduction of the constant-weight cupola blower with automatic control it was not possible to furnish the air in this manner.

In order to supply a constant weight of air giving a constant weight of oxygen it is necessary under usual conditions to be able to vary the volume approximately one-third, as the volume of one pound of air varies directly with the absolute atmospheric temperature and indirectly with the atmospheric pressure.

The idea of using constant weight instead of constant volume followed a special study of the air requirements of a cupola based upon knowledge relating to the compressing and handling of air gained in long experience building blowers. The subject was, therefore, approached from an "air" viewpoint; and during this study the importance of the problem of proper air supply to the cupola was realized. The designers of the new equipment, working in combination with the foundry, then ran a series of tests which indicated very emphatically that the cupola should be supplied with a constant weight of air in order to get consistent results and the best efficiency in the use of the fuel.

The next step was the development of a blower and control equipment which would automatically supply a constant weight of air to the cupola under all conditions.

COMBUSTION IN THE CUPOLA

The operation of the cupola being chiefly a process of combustion, a study of combustion in the cupola should be made, regarding which very complete information is contained in a number of volumes. Dr. Richard Moldenke covers the subject of combustion as related to the cupola very thoroughly in his volume, *Principles of Iron Founding*, and Dr. E. E. Marbaker has recently written a very fine paper on this subject.

However, practically all of the books and articles written on this subject previous to the paper read by the writer before the American Foundrymen's Association in May, 1928, failed to emphasize the fact that a *constant weight* of air should be used instead of a constant volume, although all the calculations are started on the basis of the weight of carbon and oxygen required.

Mr. Lawrence A. Hartley has recently published a new volume, *Elementary Foundry Technology*, with special reference to gray iron and steel in which he brings out very emphatically the importance of using a constant weight instead of a constant volume of air. Mr. J. E. Hurst, an English author, also covers this point in a recent revision of his volume dealing with foundry practice.

Amount of Air Required: Volume Method

In order to arrive at the amount of air required it is necessary to use only very simple laws covering the union of the carbon of the coke and oxygen of the air. One atom of carbon combines with two atoms of oxygen.

$C+O+O=CO_2$ or $12+16+16=44$ or
32 parts of oxygen to 12 parts of carbon.
$32\div12=2.66$ or 2.66 times as much as carbon.

Therefore to burn one pound of carbon to CO_2, 2.66 pounds of oxygen will be required. Air contains by weight 23.1 per cent oxygen, giving $2.66\div0.231=11.517$ as the pounds of air required for the perfect combustion of a pound of carbon.

Previous methods of figuring changed at this point from weight to volume by dividing 11.517 by 0.0765, the weight of a cubic foot of air at 60 deg. F. and atmospheric pressure. This gives a factor of 150; and with a ratio of iron to coke of 10 to 1 in the charges 200 pounds of coke will be required to melt a

ton (2000 lb.); therefore, the volume of air required to melt a ton of iron is 150×200=30,000 cubic feet.

Such has been for a great many years the general rule for figuring the amount of air required; in fact, so general has it become that in many cases it has been used without considering that it is based on a fixed ratio of iron melted to coke burned in the charges. Actually, this amount of 30,000 cu. ft. is based on the following:

Perfect combustion; all carbon burned to CO_2.
Iron-to-coke ratio, 10 to 1.
No air leakage.
Coke 100 per cent carbon.
Coke 100 per cent dry.
Atmospheric pressure, 14.7 lb. per sq. in.
Atmospheric temperature, 60 deg. F.
Humidity, zero.

All of these conditions change, and later on it will be shown that under certain conditions 30,000 cu. ft. would be almost twice as much air as is actually required. The old method is, therefore, decidedly incorrect; and the proper method is to compute the amount from start to finish in pounds, and to take into account all the foregoing variable considerations.

Amount of Air Required: Weight Method

Carbon Burned to CO_2. In the weight method, consideration is given to all factors entering into cupola operation and in order to arrive at the pounds of air required it is first necessary to determine the amount of carbon burned to CO_2. The air from the blower passes through the tuyers into the bed of the cupola and comes in contact with the incandescent coke; when the oxygen of the air unites with the carbon of the coke and forms CO_2 each pound of carbon so consumed evolves 14,550 heat units. Of this weight of air 23.1 per cent is used in this manner and the other 76.9 per cent (practically all nitrogen, an inert gas) absorbs heat until it reaches the maximum temperature in the cupola and passes up the stack, carrying a certain amount out of the top depending upon the opportunity it has to impart its heat to the upper charges of coke and iron.

The CO_2 formed travels up with the nitrogen, and as it comes in contact with incandescent coke further up or further into the bed or in the upper coke charges, some of the oxygen combines with the carbon in the coke and CO is formed, according to the formula

$$CO_2+C=2\ CO—5850\ B.t.u.$$

This occurs in the bed when it is too high, or the amount of oxygen is too low, or the air does not penetrate into the bed far enough; and each pound of carbon thus consumed absorbs heat to the extent of 5850 heat units, and therefore actually has a cooling effect, under the conditions existing in the bed at this point. However, it is possible that some oxygen will be present, and combining with part of the CO gas ($2\ CO+O_2=2\ CO_2+$10,200 B.t.u.). Thus 10,200 heat units will be added, and the net result will be the addition of 10,200—5850=4350 heat units, whereas burning to CO_2 would give 14,550, incurring a loss of 10,200 B.t.u.

When the CO does not have any oxygen to combine with it, the actual loss for each pound thus consumed is the 5850 B.t.u. required in the foregoing reaction in addition to the 14,550 B.t.u. that the complete combustion of the carbon would have produced, or a total loss of 20,400 B.t.u. This is what happens in the charge above the bed, where there certainly should not be any oxygen to combine with the CO; so that for every pound of carbon that burns before it reaches the bed, this loss of 20,400 heat units will occur. Such losses cannot be completely eliminated, but can be reduced to a minimum by having the proper height of bed, the proper amount of oxygen distributed as evenly as possible over the bed, and the proper charges to maintain the bed as nearly the same height as possible. As long as free oxygen exists in the bed the amount of CO gas formed will be a minimum, and some of this taking up oxygen of the air will reduce the total loss. A high bed or a low amount of air means that part of the way up in the bed there is no oxygen; only CO_2 which, coming in contact with carbon at high temperature, rapidly forms CO. With the bed of proper height and the right amount of air, a minimum of CO gas will be formed in the bed and the loss will be confined to the upper charges. Beyond a certain amount of air and coke burned in the bed for a cupola of given size the efficiency will be lowered in consequence of the larger amount of CO_2 formed in the bed which causes more of the carbon above the bed to be burned to CO; and further because of the fact that the larger amount of air and gases causes the hot gases to travel faster and thus more heat is carried out the top of the cupola.

Such considerations show the importance of supplying the right amount of air and at the same time indicate the difficulty in determining this amount. In figuring the amount of air, allowance should be made for the amount of carbon burned finally to CO by the oxygen from the CO_2, because the amount of coke thus consumed does not get its oxygen from the incoming air. An analysis of the stack gases will indicate very closely the amount of coke being burned to CO and therefore for certain operating conditions a fairly close calculation of the amount of air required can be made.

According to Dr. Moldenke one-third of the carbon will be burned to CO in good practice, one-seventh in best practice, and as much as two-thirds in poor practice. Therefore, for poor practice the amount of coke will be high, or the ratio of iron to coke low; and as the practice improves the ratio will increase. This indicates that the amount of carbon burned to CO_2 will vary directly with the ratio of iron to coke in the charges. More oxygen will be required as more carbon is burned to CO_2; but owing to the reduction in total carbon required to give best results the air will be reduced. Calculations and tests indicate that the amount of air required is reduced as the ratio of iron to coke is increased.

Carbon in Coke. In figuring the amount of air it is necessary to allow for the percentage ash and volatile matter in the coke; but good coke averages about 88 per cent fixed carbon. Where the amount varies from this figure it is necessary to change the amount of air.

Moisture in Coke. The coke should be stored in a dry place and then charged by weight; but if wet, allowance should be made for the water content. This is hard to determine, so that under this condition it is best to charge by volume although by weighing

at frequent intervals some of the coke that has been dried the effective weight of coke can be determined.

Density and Size of Coke. The density and size of the coke and whether the coke is screened will affect the amount of air required per minute. However, good coke properly screened, can be secured; therefore these factors need not be taken into consideration until such a time as some of the other factors affecting cupola operation are controlled to a much closer degree. The coke should be in pieces as near the same size as possible as large pieces will burn slower and small pieces faster thus affecting the rate at which the air should be furnished.

Air Leakage Between Blower and Bed. The air leakage is one of the easiest factors to control and should be confined to that escaping through the slag hole. With slag running continuously while the blower is running, which is essential for best operating conditions, the leakage will be very small. There is no excuse for the piping not being air-tight but leakage will occur if ordinary slide gates are used in the piping system. Hand gates of the damper type and of the same construction as the automatic gates are practically air-tight inside and outside. An ordinary slide gate two feet wide may have a leakage as high as 500 to 700 cu. ft. per min.

Leakage may also occur between the shell and the brick lining if the tuyeres are not installed properly. The tuyere sight-hole covers should be made air-tight by the use of castings having a groove filled with packing to fit over the edges of the opening.

Generally, five per cent leakage is allowed but this will vary, depending on the tightness of the system.

Humidity. Under ordinary conditions the air will carry only a small amount of water vapor. The humidity of the atmosphere changes with the weather and there will be a change in the density of the air which will involve a change in the oxygen content. Thus there will be an error at one extreme (when no water vapor at all is present) of 0.3 per cent; and at the other extreme (a very hot, humid day) of 1.5 per cent. Water vapor still contains some oxygen, so that the maximum error is something less than 1.5 per cent. This error is very small as compared with an error of over thirty per cent made under average weather conditions when a constant volume of air is supplied to the cupola.

Foundrymen who have operated their cupolas on the basis of supplying a constant volume of air have always noticed a difference in the operation of their cupolas on a rainy day in the summer time. The difference is due to the fact that the air is cooler and contains more oxygen per cubic foot and not because of more moisture in the air. There is even less moisture under these conditions, as the humidity varies with the temperature of the air.

Ratio of Iron to Coke Charges. In figuring the amount of air required, the ratio of iron to coke is the weight of iron in each charge divided by the weight of coke in each charge, and therefore does not include the bed charge. Dividing the number of pounds of iron melted by the ratio gives the number of pounds of coke burned, which must be known before the amount of air can be figured. In present-day usage in this sense, the meaning of "ratio" is obscure. In some cases it is the overall ratio of the entire plant, or the total pounds of iron charged in a whole month divided by the total pounds of coke purchased. Such a ratio is variable and therefore as a basis of comparison between any two plants or any two cupolas is meaningless, and useless in figuring the amount of air. A ratio on this basis will depend on the coke lost in transit, the amount of coke breeze, the weight of the coke bed, the number of cupolas operating, the tons of iron melted each day, the number of days operating, the amount of fresh coke used in the core ovens or for any other purpose, and the way the dump coke is used. A small plant may be operating much more efficiently than a large plant and yet the overall plant ratios may be about the same.

Similarly, one cupola may be operating more efficiently than another but if the first is operating only three or four hours whereas the other one is operating eight hours, the ratio may be the same for both if the bed is included. In both cases the amount of coke unburnt or the drop coke should be about the same.

In order to figure the amount of air and to make a comparison of efficiencies, the coke ratio should be taken as the ratio between charges less the bed charge; and any dump coke used should be charged on the basis of allowing about 10 per cent of the weight for moisture and drops of slag and iron.

The purpose of introducing coke and air is to produce a sufficient number of heat units to melt and superheat the iron to the proper temperature so that it will mix and flow properly. The amount of coke required will therefore depend on the character of the iron charges, the temperature required at the spout and the loss of heat through the lining, up the stack, and in the limestone and slag.

Assuming no loss, perfect combustion, and that coke is 100 per cent carbon, the consumption of one pound of coke would make available 14,550 heat units (B.t.u.); thus on the basis of 600 heat units being required to melt and superheat a pound of iron to 2850 deg. F. it should be possible to melt 14,550÷600=24.25 or approximately 25 lb. of iron, a ratio

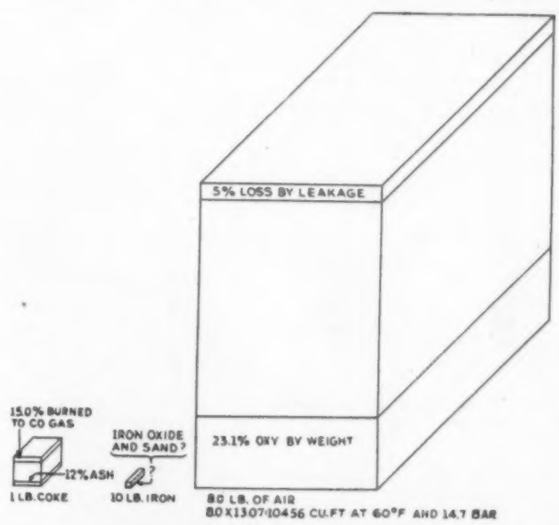

5% LOSS BY LEAKAGE
15.0% BURNED TO CO GAS
12% ASH
1 LB. COKE
IRON OXIDE AND SAND?
10 LB. IRON
23.1% OXY BY WEIGHT
80 LB. OF AIR
80 X 13.07-10.456 CU. FT AT 60°F AND 14.7 BAR

Fig. 1. Graphical Representation of the materials Entering Into the Cupola During the Charging and Melting Process

of 25 to 1. At 2400 deg. F. only about 490 B.t.u. are required per pound of iron, so that the ratio becomes 14,550÷490=29.7, or approximately 30 to 1.

In view of these considerations it would seem that a ratio between the charges of at least 10 to 1 should be secured in any case, and in practically every case where an effort has been made to supply the proper amount of oxygen at all times a ratio at least this high is maintained. This includes cases where the mixture contains 20 per cent steel and a large amount of foreign scrap, and where the iron is running 2750 deg. F. at the spout, unoxidized and melted at the rated capacity of the cupolas, the capacity in most cases running as high as 18 to 20 tons per hour and operating 8 to 10 hours per day.

With 20 per cent steel mixture, but where the temperature of 2650 deg. F. at the spout is satisfactory, 12 and 13 to 1 ratios are being secured. With lower spout temperatures, no steel, and higher phosphorous content, ratios of 14 to 1 are being secured in both large and small cupolas and ten-hour melts.

An iron-to-coke ratio of 10 to 1 in the charges is considered average, 12 to 1 very good, and 14 to 1 about the best that can be expected with our present knowledge and design of cupolas.

Comparison of Materials Charged. On the basis of a 10 to 1 ratio a comparison of the amount of iron, coke, and air charged into the cupola will be interesting and will emphasize the importance of using the correct amount of air. This is shown in Fig. 1. The block on the right shows the relative space occupied by the 8.0 lb. of air required to burn 1.0 lb. of coke and melt 10 lb. of iron. One pound of air at 60 deg. F. and 14.7 lb. per sq. in. barometer occupies 13.07 cu. ft. so that 104.56 cu. ft. of air are required per pound of coke. The portion blocked off at the bottom shows the corresponding amount of oxygen,

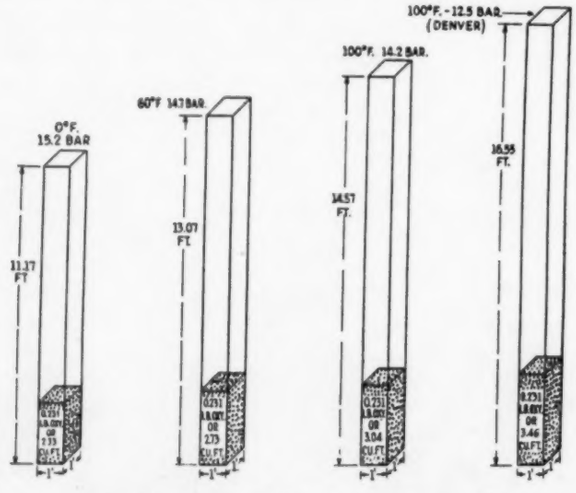


Fig. 2. Graphical Representation of the Changes in Volume of Air Under Different Conditions of Atmospheric Temperature and Pressure

which is 20.9 per cent by volume or 23.1 per cent by weight, or the proportion of the total air charged used for combustion. The other 76.9 per cent, largely nitrogen, to a certain extent defeats the purpose for which air is charged into the cupola. The part blocked off at the top shows the amount lost by leakage.

The block at the left shows the relative space occupied by a pound of coke, the lower section of which shows a loss of 12 per cent on account of ashes and the upper section a loss of 15 per cent on account of the part burned to CO instead of CO_2.

The small block of iron weighs ten pounds and has a very small percentage loss due to rust and sand. Therefore, about 75 per cent of the coke and iron charged accomplishes the purpose for which it is charged, whereas only about 23 per cent of the air does effective work. The weight of the air is almost as much as the combined weight of iron and coke; by the volume method it is actually more.

Temperature and Barometer. Fig. 2 illustrates very clearly that constant weight of air is not necessarily constant volume, and that the air should be figured by weight instead of by volume in order to provide a constant weight of oxygen. For constant weight, the volume varies directly with the absolute temperature and inversely with the barometric pressure. This chart shows that at 60 deg. F. and at a barometric pressure of 14.7 lb. per sq. in. (standard conditions) 1.0 lb. of air occupies 13.07 cu. ft. At 0 deg. and 14.7 lb. the air is contracted so that 1.0 lb. now occupies 460/520×13.07=11.56 cu. ft. At this temperature the pressure may be as high as 15.2 lb. per sq. in., when 1.0 lb. of air will occupy 14.7/15.2×11.56=11.17 cu. ft. This still gives a constant weight of 0.23 lb. of oxygen, but the volume has decreased to 0.209×11.17=2.33 cu. ft.

At 100 deg. F. the pound of air is expanded to 560/520×13.07=14.08 cu. ft. and at this temperature the barometer may show a pressure as low as 14.2 lb. per sq. in., in which case 1.0 lb. of air will occupy 14.7/14.2×14.08=14.57 cu. ft. and the volume of oxygen will be 0.209×14.57=3.04 cu. ft.

The right-hand column in the chart shows the probable maximum requirements in this country. For instance, in Denver (Colo.), where the summer temperature may be as high as 100 deg. and where the barometric pressure is normally 12.5 lb. per sq. in., the volume occupied by 1.0 lb. of air is 460/520×13.07×14.7/12.5=16.55 cu. ft. In this case the volume of oxygen is 0.209×16.55=3.46 cu. ft.

Thus supplying a constant volume of air to the cupola will not produce consistent melting results on account of the changes in atmospheric conditions from hour to hour, day to day, and month to month, because these vary the amount of oxygen.

At zero and 15.2 lb. per sq. in. barometer, 11.17 cu. ft. of air is required,while at 100 deg. and 14.2 lb. per sq. in., 14.57 cu. ft. is required. This means that, in the winter, 14.57 cu. ft. is 30 per cent too much air. The amount required at Denver in summer as compared with amount required at sea level at zero and 15.2 lb. per sq. in. is 16.55/11.17=1.49, or approximately 50 per cent excess.

Fig. 3 gives factors for determining the volume of air required at various temperatures and barometric pressure for a constant amount of oxygen, based on standard conditions (60 deg. F. and 14.7 lb. per sq. in. barometer). This shows, by applying these factors to an actual case where the cupola is melting 14 tons per hour and 7000 cu. ft. is required at 60 deg. and 14.7

lb. per sq. in., that at zero degrees and 15.2 lb. per sq. in. only 6000 cu. ft. is required; at 100 deg. and 14.2 lb. per sq. in., 7700 cu. ft.; while at Denver at 100 deg. and 12.5 lb. per sq. in. the amount is 8860 cu. ft.

Pounds of Air Required per Minute

In figuring the amount of air required in pounds per minute it is necessary to take into consideration the following important factors:

2.66 =lb. of oxygen required per lb. of carbon
0.231=lb. of oxygen per lb. of air.
11.517=lb. of air per lb. of carbon (2.66÷0.231)

C=per cent fixed carbon per lb. of coke
M=dryness factor of coke charge (in per cent)
Y=per cent carbon burned to CO_2.
A=per cent air from blower reaching bed
T=tons of iron melted per hour
R=ratio of iron to coke in charges, by weight

The following formula can then be used:

Pounds of air required per minute

$$= \frac{11.517\,CMYT}{60\,AR} \times 2000 = \frac{385\,CMYT}{AR}.$$

If the coke is dry and the leakage is average, M will become unity, A will be 0.95, and the formula will be reduced to

$$\frac{406\,CYT}{R}$$

Using an average value of C as 0.88, it reduces to

$$\frac{357\,YT}{R}$$

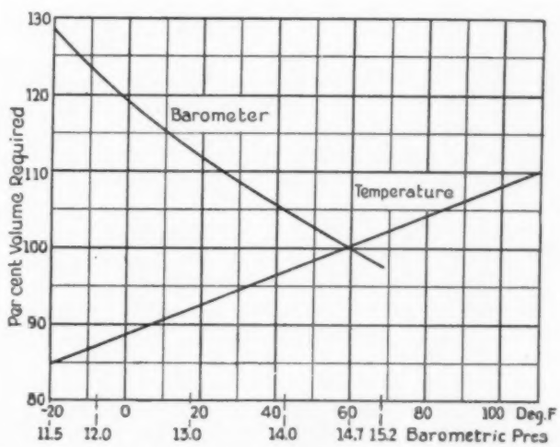


Fig. 3. Chart of Factors to Correct for Variations of Temperature and Pressure from Normal (60 deg. F. and 14.7 lb. per sq. in.) in Determining the Volume of Air Required to Yield a Given Quantity of Oxygen

Recent tests indicate that, with a 12 to 1 ratio between charges, 85 per cent of the carbon is burned to CO_2; at 10 to 1, about 75 per cent; and as the ratio was reduced this percentage was reduced about five per cent for each unit reduction in the ratio. The accompanying tabulation (Table I) which is based on the preceding calculations and assumptions, indicates the amount of air required for various ratios.

Table I
POUNDS OF AIR PER MINUTE PER TON OF IRON MELTED PER HOUR

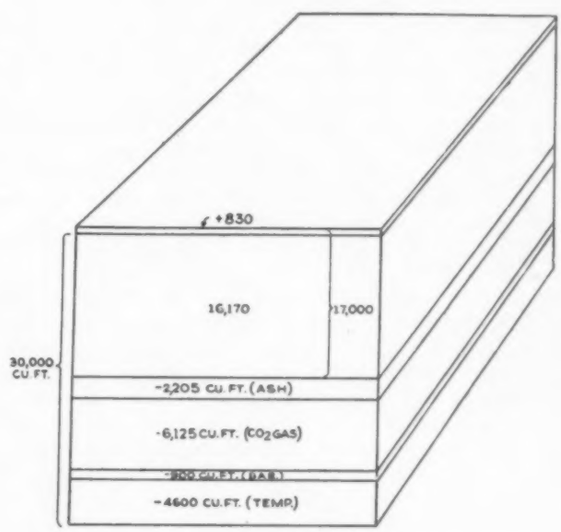
Ratio	Value of Y	Lb. Air Per Min.
12 to 1	0.85	25.3
11 to 1	0.80	26.0
10 to 1	0.75	26.8
9 to 1	0.70	27.8
8 to 1	0.65	29.0
7 to 1	0.60	30.6

The fact that only five per cent leakage is allowed should be emphasized; and in case the wind box, pipe line, and gates are not tight and a big slag hole is used, it will be necessary to increase these figures.

Comparison of Volume and Weight Methods

Table II gives the amount of air per ton of iron melted, using both the weight method and the volume method, based on standard condition of 60 deg. F. and 14.7 lb. sq. in. barometer.

The cu. ft. values under the weight method are the lb. of air divided by 0.0765 (the weight of a cu. ft. of air at standard condition of 60 deg. F. and 14.7 lb. per sq. in.). The volume method values are based on the old rule of 30,000 cu. ft. per ton with



Reduction due to -20° temp. gives $30{,}000 \times \frac{440}{520} = 25{,}400$

Reduction due to 15.2 bar. gives $25{,}400 \times \frac{14.7}{15.2} = 24{,}500$

Reduction due to 75% of coke burned to CO_2 gives $24{,}500 \times 0.75 = 18{,}375$

Reduction due to 12% ash in coke gives $18{,}375 \times 0.88 = 16{,}170$
Addition for 5% air leakage gives $16{,}170 \div 0.95 = 17{,}000$
$30{,}000 \div 17{,}000 = 1.765$, or approximately 75% excess

Fig. 4. Graphical Representation of the Various Excesses Occasioned in the Use of an Arbitrary Volume of 30,000 cu. ft. of Air Per Ton of Iron Instead of the 17,000 cu. ft. Actually Required at 20 deg. F. and 15.2 lb. per sq. in.

ratio of 10 to 1, and as the ratio is increased or decreased the amount of air is decreased or increased respectively.

Fig. 4 emphasizes the error made in using 30,000 cu. ft. of air per ton of iron based on a 10 to 1 ratio.

Table II
AMOUNT OF AIR REQUIRED PER TON

Ratio	METHOD		
	Constant Weight		Constant Volume
	Lb. of Air	Cu. Ft. at 60 deg. F. and 14.7	
12 to 1	1518	19,860	25,020
11 to 1	1560	20,400	27,300
10 to 1	1608	21,000	30,000
9 to 1	1668	21,840	33,300
8 to 1	1740	22,740	37,500
7 to 1	1836	24,000	42,900

This diagram represents the error thus made in an actual case when the temperature is 20 deg. F. below zero and the barometer indicates 15.2 lb. per sq. in. The reduction in the volume of 30,000 cu. ft. due to -20 deg. temperature gives $30,000 \times 440/520 = 25,400$ cu. ft., which, owing to the higher pressure (15.2 lb. per sq. in. barometer) becomes $25,400 \times 14.7/15.2 = 24,500$. The reduction due to incomplete combustion (only 75 per cent of coke is assumed to have burned to CO_2) gives $0.75 \times 24,500 = 18,375$ cu. ft. A further reduction due to ash in the coke gives $18,375 \times 0.88 = 16,170$. Addition for leakage gives finally $16,170 \div 0.95 = 17,000$ cu. ft., whence $30,000 \div 17,000 = 1.765$, showing approximately 75 per cent more than required.

Certain types of blowers and certain types of meters have been developed with the idea of securing constant volume. However, even the perfect operation of these machines and meters will give the serious discrepancies illustrated at one extreme or the other so that, even if there were some perfect means of supplying a cupola with a constant volume of air, and if this volume were exactly correct at one extreme, it would be seriously in error at the other.

Effect of Excess Oxygen

For perfect combustion, a definite weight of oxygen should combine with a definite weight of carbon in the coke to give carbon dioxide gas in the melting zone. Thus if too much oxygen is supplied, free oxygen will exist and combine with the iron in the melting zone; the result is oxidized or burnt iron. Furthermore, the excess oxygen carries more nitrogen which increases the cooling action, so that the iron is not only burnt, but is cold. Twenty-three per cent of the air is oxygen, which is the agent promoting combustion, and the other 77 per cent is largely nitrogen and inert gas which is heated to the maximum temperature in the cupola and then discharges into the atmosphere having done but very little work. As it passes through the successive layers of iron and coke it gives up some heat; but with excess air it travels at such a high velocity it has time to give up only a small percentage of its total heat content. Excess oxygen, therefore, means not only oxidized iron but the iron is cold and spongy; and excess air not only increases the speed of blast but causes high wind box pressure and greater burning of the lining.

Effect of Insufficient Oxygen

Insufficient oxygen means that the oxygen is all consumed in combining with the coke in the lower part of the layer of coke just at the melting zone. Carbon dioxide is formed but of an insufficient amount, which encountering the incandescent coke in the upper part of the layer of coke just under the melting iron is converted into carbon monoxide gas, and each pound of carbon thus consumed robs the bed of 5850 B.t.u. This occurs in the regions just where the maximum number of heat units to be secured by forming carbon dioxide are required. The result may be both cold iron and slow melting with the possibility of bridges forming. If the bed is high and the ratio low, there may be sufficient air to burn enough coke to CO_2 in the bed to furnish the heat required for melting hot iron; but the melting rate will be low, and a great deal of coke will be wasted.

Method of Operating Cupola

Certain methods of operating cupolas have prevailed for a great many years; yet in no two foundries are the methods alike. The method used on one cupola, while giving good results most of the time, might not work at all in a cupola of the same design in another plant. Obviously, this should not be the case, and some standardized method should be followed.

There has been in the past a great deal of mystery connected with the operation of a cupola inasmuch as it is not possible to see just what is going on inside. Results have varied in different plants and from day to day in the same plant because of the three chief variables, iron, coke, and air, only the first two have been under control and very little effort has been made to control the air, as though the important part that air plays in the successful and consistent operating of the cupola had not been appreciated.

After the calculation of the amount of air required, practical operation involves so many variables that the operator feels that he can be sure of one thing—plenty of air—and, therefore, in most cases uses too much. Too much is the cause of most troubles; and the variation in the oxygen is generally the cause of inconsistent results. Recognizing that air is just as important as coke, although available at only a fraction of its cost, means that the foundryman should have the proper air equipment in order to get the best results. Using the constant-weight cupola blower with automatic control makes it readily possible for him to determine the correct amount of air, after which the apparatus can be set to automatically supply day in and day out the correct amount of air irrespective of the changes in the temperature of the air, barometric pressure, and ordinary changes in resistance to the flow of air through the cupola. In the development of this apparatus and the installation of about 150 equipments a great deal of experience has been gained; and what follows in this article deals with the various factors which bear an important relation to more successful cupola operation.

Best Operating Results

Ordinarily the first consideration in cupola practice is to secure hot iron, but iron can be hot and still not be of the proper mixture, or it can be hot and still not hold up its heat, and therefore freezes quickly, so that by the time it is ready to pour it is

entirely unfit for pouring. The difficulty of improper analysis or mixture and the freezing of the iron is due either to an improper mixture to begin with or too much air burning out the coke, lowering the bed, and therefore burning the iron. Too much air not only changes the analysis but effects the fluidity of the iron and the strength of the resulting casting. Observation of the temperatures by the naked eye or by pyrometer usually indicate whether the iron is hot enough. A better check, however, is to pour samples into a fluidity-test mold, using iron direct from the spout. If iron at this point is satisfactory, defective castings should not be chargeable to the melting of the iron, but rather to mishandling, or other causes.

Best results depend on:

(1). Starting with the right mixture
(2). Starting with a proper bed
(3). Maintaining a proper bed
(4). Starting with the proper supply of air
(5). Maintaining the proper supply of air;

and are indicated by:

(1). Consistent analysis of melted iron
(2). Consistent temperature of melted iron
(3). Consistent fluidity of melted iron
(4). High iron to coke ratio—at least 10 to 1 in the charges (less bed).

Efficient operation is indicated by the elimination of practically all of the flame at the charging door, when the total charge is 12 to 15 feet deep, and only warm gray smoke rolling up.

Operating More Than One Cupola with One Blower

The blower should supply air to only one cupola at a time, and in case it is used to supply air to a certain size cupola on one day and a larger or smaller cupola on the next, it should of course be large enough for the large cupola and then run at a lower rating on the smaller cupola. The piping in this case should have, in addition to the automatic blast gate, properly designed hand gates of the damper type to direct the flow of air into either cupola, as desired. The damper-type gates are of the same construction as the automatic gates and are practically air tight. These should be used instead of the ordinary slide gate which may permit the outward leakage of a large amount of air, not only occasioning great waste, but making it very difficult to determine the correct amount of air to use in order to make up for that which is being lost. An ordinary slide gate 2 ft. wide may have a leakage from 500 to 700 cu. ft. per min.

Tuyeres

The construction of the tuyeres should be such that the air is evenly distributed around the cupola and they should have the proper height to give enough velocity to the required air to cause it to penetrate into the center of the cupola. They should be continuous and have a height from two to six inches. The smaller the height, the higher is the velocity of a given amount of air and, therefore, the better is the penetration. Changing the height has no appreciable effect on the wind box pressure for a given amount of air, because the length of the path the air has to travel passing through the tuyeres is very short. Five-inch tuyeres on a cupola with 54 in. inside lining have been plugged with brick down to a height of two inches and no effect on the operation of the cupola, wind-box pressure, or the cutting of the lining determined.

Changing the size of the tuyeres is generally supposed to affect the "speed of the blast" and, for the correct amount of air, varying the height of the tuyere will affect the speed of the air entering the cupola as explained; but the speed of the blast is the amount of gases passing through the bed at any certain plane divided by the area of the open spaces in this plane. For a given area the speed of the blast will be affected only by the amount of air being used.

It is assumed that no upper tuyeres are now being used as it has been determined time and time again that they are not only unessential, but make it necessary to increase the height of the bed an amount equal to the distance between the tops of the lower and upper tuyeres.

Bed

The function of the bed is to develop a sufficient number of heat units to melt a given output of good hot iron in a given time with a minimum waste of heat. Therefore, a certain amount of incandescent coke will require a definite amount of oxygen in a given time, in order to burn the maximum amount of carbon in the fuel to CO_2 and a minimum of CO gas, thereby obtaining the best efficiency. Each pound of carbon burned to CO_2 gives 14,550 heat units, whereas every pound burned to CO requires 5850 B.t.u. to complete the reaction, and incurs the loss of heat that would otherwise have been available, as previously shown; therefore the bed of the cupola should be operated like the bed of fire in any furnace, burning the proper amount of fuel and the correct amount of air at all times, thereby securing more heat per pound of fuel and utilizing the heat for the purpose for which it is generated instead of forcing it out the stack.

The kind of fuel used in starting the bed is unimportant just as long as the bed is well lighted throughout and is thoroughly incandescent in front of the tuyeres. In some foundries, square holes the size of two bricks placed on edge and lengthwise are made in the wall to allow a better draft on the wood or to allow the use of oil or gas burners. These holes are filled with fire brick as soon as the bed is thoroughly lighted.

With the cupola lined up approximately the same each day, the amount of coke in the bed can best be determined by measuring from the charging door. After the bed is burned through until it glows red all over and the coke shows red through all the tuyere openings, about six to ten inches of coke should be added to bring the height of bed up to approximately 20 or 30 in. above the top of the tuyeres. The tuyere openings should then be closed to prevent the bed from burning out excessively and, therefore, starting the cupola with too low a bed. In starting with a 20 to 30 in. bed, it is intended that this shall remain the height of the bed when the wind is turned off; if the bed is much over 30 in. in height, it will not be possible to get the best operating conditions.

The coke bed is of the utmost importance, and unless it is lighted properly, started at the right height, and maintained at this height throughout the entire run it will be impossible to get the best and most consistent results.

(To be continued)

Safety in Industry †

By I. LAMONT HUGHES*

It is thirty-three years since my connection with industry began; starting in at the great Edgar Thomson Steel Works at Braddock, Pennsylvania. This plant, as many of you know, was built and operated by the great Captain Jones—a man who had few equals in the handling of men and the production of iron and steel, a man who loved his fellow men and assisted many widows and orphans who lived in Braddock and vicinity.

You will recall that when the news of the great disaster caused by the Johnstown Flood in '89 was flashed over the wires to all parts of the country, this great and humane man took it upon himself to shut down the Edgar Thomson Works and, loading his men on freight cars, they set out to give first aid to their countrymen, many of whom were fellow steelworkers of former days. To tell of what these first aid men accomplished on this occasion would make a volume of very interesting reading—to tell of the deeds performed by these men of steel would equal any such achievements in history. But much as we would like to extol and sing the praises of these pioneers in industry, we cannot but think that if the safety movement had been in the foreground as it is today—perhaps this one of the great disasters of this country would have been averted. Four months after the Johnstown Flood, Captain Jones and three of his men were killed as a result of a Blast Furnace explosion. The Captain met death while leading and directing his men; trying to get a sick furnace to right itself in the making of regular production of iron.

Forty-one years have come and gone since then. The dangers and hardships endured by those hardy giants in industry have almost disappeared. The slogan of "Safety First" has made a new order of things. In the old days through lack of money and engineering skill, men were subject to the hazards of steel making which are avoided now. Today, machinery is doing the hard and dangerous work that men used to do with their hands. The steel industry has spent millions to reach this end. Every drawing in connection with improvements is checked—every new idea in the manufacture of steel is scrutinized carefully before its adoption to permit the greatest degree of safety. The men in the mills are taught safety, every man in the organization is talking safety, and now at this present date, I can truthfully say that in the once dreaded steel making industry there is a safe place to work, and the environment and surroundings are as agreeable for our steel makers as they are in any industry in this country.

The other day when looking over the booths erected for this occasion in William Penn Way, I came upon our own Carnegie Steel Company exhibit. There is a picture showing the husband and father bidding goodbye to his wife and child as he goes to his daily task. Under this picture is the inscription "Their Safety Is His Responsibility." There is another picture showing the same man working in front of the fiery furnace at one of our steel mills. Underneath this picture is inscribed "His Safety Is Our Responsibility." We, as employers of labor, cannot and do not want to get away from this responsibility, but there is one thought I would like to leave with you; that is, a great many of our accidents are caused by the thoughtlessness of the injured man himself or by an equally indifferent fellow workman—some of these men may be old and trained employes. The only conclusion you can come to for this class of accidents is that these men may not be as happy as they might be; that they have worries of some kind in their minds which take away their usual alertness and they eventually become involved in a serious accident that we or no one else can decide the cause. Thoughtlessness and indifference are the greatest enemies to real safety.

About ten years ago we adopted a plan that has proved very helpful. We put safety on a competitive basis—made it a game, so to speak, a competition among our various plants. The thought that if there were some tangible object to attain, some goal to reach, the men would enter a contest to win it. It is human nature to want to beat the other fellow. The trophies are handsome pieces of bronze and silver and carry a legend with them that is interesting. The men grasped the spirit instantly and through ten years now have not lost interest in the competition for the safety trophy. The plant winning the trophy one month holds it and displays it at its works for the following month. At the end of the year the trophy becomes the property of the plant making the best yearly record in safety. One story is told of a superintendent whose mill was piling up a long record for no accidents, when one day a man who had no business with a sledge hammer in his hand let it fall on his foot. The record was broken. It is told that the superintendent actually wept, and that the men almost ostracised the injured man for his carelessness.

Another safety idea that has been valuable is the calendar Carnegie Steel Company publishes every year. More than 60,000 of these calendars go over the country—requests even come from foreign countries. The appeal is made through school children. The pictorial work on the calendar is reproduction of safety posters made during a contest in public and parochial schools in the towns where our mills are located. Each community carries on its own contest, has its own judges and awards its own prizes. Then the plant safety committees send in their selections to the General Safety Committee for final choosing of posters for the next year's calendar.

Good housekeeping is also something that should not be overlooked. Show me a well-kept, orderly plant and I will show you a plant with a fine safety record. A tidy plant begets a tidy organization. Tidiness begets carefulness; carefulness insures safety.

In concluding I wish to say that it is our constant aim to talk safety, act safety-first, last and all the time, regardless of tonnage, cost or any other part of the making of steel. We freely endorse these anonymous lines which many of you have read, viz:

"And the end is that the workmen shall live to

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*President, Carnegie Steel Company.

enjoy the fruits of labor; that his mother shall have the comfort of his arms in her old age; that his wife shall not be an untimely widow; and that his children shall have a father; and that cripples and helpless wrecks who were once strong men shall no longer be a by-product of industry."

Should Colleges and Universities Create a Safety Course†

By J. A. VOSS*

DISCUSSION

Discussed by

Dean Keefer, National Safety Council, Chicago, Ill.
Walter Greenwood, Youngstown, Ohio.
Earl F. Blank, Chief Safety Director, Jones & Laughlin Steel Corporation, Pittsburgh, Pa.
C. L. Baker, Management's Representative, Bethlehem Steel Company, Lackawanna, N. Y.
M. M. MacDonald, Electrical Superintendent, Andrews Steel Company, Newport, Ky.
J. D. Donovan, Supt. of Electrical and Mechanical Department, Republic Steel Corp., Massillon, Ohio.
James Farrington, Electrical Superintendent, Wheeling Steel Corporation, Steubenville, Ohio.
W. H. Burr, Electrical Superintendent, Lukens Steel Company, Coatesville, Pa.

Dean Keefer: I want to endorse the things that have been said by your speaker Mr. Voss, he has covered this subject splendidly. I am particularly in favor of the idea which he has advanced to this effect: that it is probably not desirable at this time to have more than one of two engineering colleges start courses through which they will turn out graduates with the title or degree "safety engineer." On the other hand, it seems to me that it is desirable to start courses in engineering colleges that will give all engineers an insight into accident prevention work.

What do engineering students do after graduation? Don't the majority of them go either to plant operation jobs into drafting or designing. Their interest and real knowledge of safety if acquired while still in college will stand them in good stead no matter what their jobs may be, no matter what industries they may go into.

I have been with the National Safety Council some eleven years. The first job related to this very problem was given to me. We prepared a little pamphlet for distribution to college professors. In that pamphlet we presented several lecture outlines and a bibliography which would help these college professors to include safety in their existing courses. Part of my job was to go out into the engineering colleges and influence the professors to use this pamphlet. It was an extremely difficult job. The first year I went to some twenty-five engineering colleges, interviewing in many cases the entire engineering faculties, trying to get over this idea, trying to get to them the conception that it was part of their responsibility in educating engineers to give them some insight into safety, so when their graduates went out into industry they would be better qualified to do their jobs.

It is interesting to note the reception I was given in several colleges. For instance, at one college where I had an opportunity to speak before the engineering faculty, a committee was appointed to make a further study of our plan and to develop come practical method whereby it could be carried out. A month later I received a letter from the Chairman of this faculty committee. He said, "We have gone into this subject very carefully and have come to the conclusion that the best thing we can do is distribute copies of your pamphlet to all of the graduating students of our engineering college."

This wasn't at all the thing we wanted them to do. This wasn't at all the job we had cut out for them. I came to this tentative conclusion: that perhaps many of the engineering college professors have become so set in their methods of presenting their courses that they couldn't yet visualize progress along our line. In other words, perhaps the Chairman of that committee had been giving lectures and supervising classroom work on machine design for some twenty-five years. And he had extreme difficulty in including accident prevention as an integral part of his work. On the other hand, the younger professors at other colleges did get the idea and they succeeded in putting into their courses many references to which they had not considered previously.

I think that is the thing we must aim for in our college engineering work. It is not nearly so important to turn out graduates with a degree of "Safety Engineers" as it is to give all engineering students a knowledge of the real fundamentals of acident prevention. The Councils success in grade school work is based on a similar plan. Instead of adding new courses in safety, safety is taught as an integral part of existing courses such as geography, writing, arithmetic, reading, etc. Let me illustrate this by a brief example. How many of us when we went to school were required to add peaches, pears and plums, and slate pencils, dogs and cats.

Such problems are unheard of in this day and age. Instead, the children in the lower grades are

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*Safety Director, Republic Steel Corporation, Youngstown, Ohio.

asked to solve such a problem: if the population of Buffalo, N. Y. was 485,000 and last year 15 persons were killed by accidents, how many were left? A simple problem in arithmetic, of course, but fortunately it can probably be made more complicated for children in higher grades. First you have the Buffalo problem. Then add this: if Pittsburgh had a population of 822,000 and 42 were killed by accidents, which city has the highest fatality rate?

That is a simple example illustrating how injecting safety into existing courses not only teaches facts about accidents prevention, but also makes uninteresting courses of real interest to the students.

I am very much in favor of Mr. Voss's ideas for including safety in educating students in our engineering colleges.

Walter Greenwood: I feel that the subject of education is the all-important one in the work of accident prevention, but it seems to me as though these who are advancing the idea that colleges and universities should create a Safety engineering course, had but little conception of how one should be started and what it should consist of. Education so far as it has been acquired, does not seem to have done all it should have toward preventing accidents. The codes provided by the various state government authorities, are constructed with education in view and enforcement of them, safeguards against accidents. I cannot see where education has done more than specify that safeguarding must be done. The education required to qualify for constructing equipment so that it can be safely operated is included in the training of the engineers that provide it and the superintendents that operate it. To show that something of importance beyond education is lacking I will allude to the Titanic disaster which should be fresh in the minds of everybody. The builders of that ship knew as much about constructing for safety as any institution of learning could teach them and that knowledge was applied to make it faultless in construction and equipment, but it seems evident the disaster was chargeable more to mismanagement than to fault of building. Some reports indicated that testing of equipment might have confined the consequence of the accident to property damage alone, anyhow to a delay of sinking that would have permitted rescue of passengers and crew.

To induce institutions of learning to create a safety course it might be well to organize a committee composed of persons of wide experience in the work of accident prevention, construction and mechanical engineers and teachers, to outline the main features of a course that would be suitable for teaching the methods that should be employed for preventing accidents. Unless this is done we may not get far in the matter of getting the resolution we are discussing adopted by schools. I may have the wrong idea but it seems as though education for accident prevention consists only of instilling the importance of the subject and the necessity for caution into the minds of students.

The engineers of this Association know how equipment should be constructed for safe operation and they know how to operate it safely but, as with all kinds of mechanical equipment, there can be no method provided to compel managers to see and adopt their ideas, especially where providing capital is a consideration. As an instance bearing on this phase of the subject, all engineers in this organization know the importance of providing interlocking devices between oil switches and circuit breakers on high tension equipment, that will prevent the opening or closing of circuit breakers while the oil switch is closed. When this subject is discussed some managers—not all of them—will argue that there is no reason for employing operators that are careless enough to do such a thing. The reason why some accidents occur is, too much reliance is placed on dependibility of operators.

Earl Blank: Seeing that I have been suggested as a speaker, I will just say a word in addition to what Mr. Keefer has told you. You can see that the National Safety Council hasn't been exactly asleep on this problem when eleven years ago they started out and made a canvass of some of the engineering schools and colleges in an attempt to get accident prevention into the existing courses.

We haven't met with the success that we feel we should have. Some of the schools have done something and others haven't done very much with it. Recently, I was appointed on a committee to bring in a recommendation to the Executive Committee of the National Safety Council on how we could better get safety into the engineering schools and colleges. That committee made a report a short time ago in which they suggested that some sort of text, or a similar educational program be prepared to that which is used in the public schools in the elementary grades, to get safety into the engineering college courses. In addition to that, the committee recommended that some action be taken to attempt to get the colleges to incorporate safety engineering courses in their curricula.

I think Columbia University is the only school that has a course in safety engineering. It is extension work. I understand the University of Pittsburgh is going to incorporate a course this fall into their curriculum. Those are the only two so far that have done anything along the lines which Mr. Voss has suggested.

I don't know whether Professor Hallack, of the University of Pittsburgh, is here today or not. (No) Professor Halleck is working on his course, will be working on it all summer, and he told me on the telephone a few weeks ago he was going to try to get over to this meeting. I thought if he were here it would be interesting to hear from him what his ideas were along this line, and how he was going to shape up this course for safety engineering.

I would like very much to get an expression from some of you fellows who are working on the industrial side, as to what you think of the subject which Mr. Voss has presented. I would like to hear from the men who are out in the electrical engineering end, or other branches of industrial engineering, as to what they think of the practicability of it. I know when we want to break in a safety man we like to have someone who has had some real, honest-to-goodness training. We have to spend a lot of time breaking in safety engineers. What we usually do is to go out and pick out some foreman who has been outstanding for his safety activities, and then start trying to teach him the technique of accident prevention work. It isn't always the easiest job. If we had a few of the schools specializing in safety

engineering we know it would be very helpful. The students at least would have some idea of the fundamentals of accident prevention work and they would have some idea of the engineering side of the problem, as many of them do not have that to start with when you start with a practical man. Then you have to start to develop from that.

I would like to hear from some of the engineers on that subject.

C. L. Baker: We would like to hear some electrical engineer give us his views on this matter. Let us put it another way. About four years ago an official of one of the large steel plants put it in these words at one of our meetings: "If the engineers do not break in on this safety matter; the safety is going to break in on them." His career has been marked since that time. He said a lot of other things along safety lines. We have safety engineers here today, who have spent a lot of time, study, and thought on this matter, and they are making progress in their plants. We are anxious to hear from you engineers on the firing line as to what you have in mind on this question.

M. M. MacDonald: In connection with the previously mentioned suggestions, it occurs to me that perhaps the various universities located throughout the country might have similar evening classes as those of the University of Cincinnati. These evening classes are composed of men from various occupations, and if there be a suitable number of men interested in a particular subject, such as, instructions for engineers in safety, and this subject is not being taught, an instructor or professor, capable of teaching this subject, is employed. It is permissable for any engineering day student in the university to attend these classes without any additional increase to their tuition fees, and thereby, educate himself in a subject not presented in his daily classes.

I have attended the above mentioned classes, and the thought occurred to me that possibly the National Safety Council officials, the officers who are here today, might attempt to interest other colleges in classes similar to those formed at The University of Cincinnati.

We have experienced no difficulty in interesting those in charge at The University of Cincinnati in regards to any subject we might want to take up and have asked for new subjects from year to vear. The National Safety Council might select available men and these men request the colleges to offer courses similar to those above mentioned, without question of doubt those of us who are interested in that sort of thing could derive a great deal of benefit from a course of this kind.

A gentleman brought the question up a few minutes ago of the companies who are perfectly willing to spend money for guards and safety devices, and those who are not. I think it is up to those of us who are engineers to sell our companies the idea of safety.

If we cannot sell our companies our idea of safety either the idea is no good or it is not ably presented, of course we do not want to offer an idea that is worthless. If we are incapable of presenting good safety ideas to our companies, a class in safety, would soon enable us to present our idea in a capable manner, and therefore, sell our companies on safety. On the other hand, safety devices are available in some plants but are not made use of in the proper manner. I have in mind a case where a man was employed with a railroad company as a track foreman for some forty years. He left the railroad and went to work for an industrial concern where on every standard gage track he worked he would place his warning flags. At one time he had the occasion to go off the standard gage and go to work on the narrow gage, and he neglected to use his warning flags. The man operating a small narrow gage locomotive with a signal device on it neglected to use the signal device. That foreman was run over and killed just because the safety devices were not used. It spoiled a record that was an enviable one, a very, very good one, one that had been hard to obtain, and the foreman lost his life at the same time.

What are you going to do with that type of man? To my mind the safety devices were there. Those men had been instructed, but they had neglected to use the safety devices and had paid no attention to their safety instructions.

It is purely a question of education on behalf of the engineers themselves in order that they be able to sell safety ideas to the management. After the safety devices are furnished some one should instruct and educate the men using these devices just how valuable they are, and not to forget their usage, as in the case which I just mentioned.

J. D. Donovan: I heard Mr. Voss's paper and I think it is wonderful. I think the idea of a safety engineering course in colleges is good and is something that should have been developed years ago. We have engineering courses for every other line, such as electrical engineering, mechanical engineering, metallurgical and many other courses, but we haven't any special training in safety engineering. If a safety man is going into a plant and if he is going to do his job properly, he has to know all of the jobs in the plant. Mr. Blank says they have a difficult time breaking in safety men. I don't doubt that statement one bit, because if you start a young fellow in safety work, many times he does not know the mechanics of the plant, and therefore knows very little about safety and it is difficult and expensive to properly train him. I do think there is quite a field for safety engineering if there were regular courses on the subject. There is a lot to be gained from a course teaching men the angles of the game. In the first place, the men you put in would be better fitted for selling their stuff, which is a very important proposition, if they had special training along those lines. He would know what he wants to sell. He could be trained to sell that, and that in my mind is the greatest thing in safety today.

Earl Blank: I wonder if we could get an expression of opinion on this subject of getting accident prevention into engineering colleges from this group that are here? I think from Mr. Voss' paper, what has been said here, and what the National Safety Council is trying to do, you have an idea of the way the thing is to be set up. Dean Keefer spoke of the work that is being done in the public schools. Our recommendation was that the same idea be incorporated in our present engineering

courses by working in problems in safety, and working it into the present course rather than making some sort of extra curriculum work, which we feel there has been more or less resistance to because of the extra work for the professor. It takes extra time. Our recommendation was two-fold: that we work this proposition into the present courses and that we do whatever we can to encourage the inauguration of safety engineering courses in the engineering colleges.

I wonder if we could ask for a vote of those who think it is a worth while project and those who don't, so we might report back to the National Safety Council that this vote was taken at this safety meeting of the Association of Iron and Steel Electrical Engineers, to help guide the committee which is working on the project at the present time?

C. L. Baker: I am going to ask that you make a motion to see if it is endorsed by the men in this room, along the line that the National Safety Council is working on, whether the Safety Section and the Iron and Steel Electrical Engineers do or do not endorse this idea of teaching safety in some manner in the engineering colleges. I believe that is the way for us to find out whether or not we desire to back up the stand that has been taken by the National Safety Council.

James Farrington: Mr. Chairman, I move you that the Association of Iron and Steel Electrical Engineers vote their approval of encouraging the colleges and universities to incorporate in their curriculum a course in safety engineering.

W. H. Burr: I second this motion.

C. L. Baker: It has been moved by Mr. Farrington of the Wheeling Steel Corporation, and seconded by Mr. Burr, of the Lukens Steel Co., that the Association of Iron and Steel Electrical Engineers endorse this movement of having the colleges and universities incorporating in their curriculum a safety engineering course. Are there any remarks? I would like to have a standing vote on this.

The motion was carried unanimously.

We certainly could not ask for a more favorable expression from this meeting than the unanimous approval you have given to this educational feature of the National Safety Council.

Description of Equipment Installed at Great Lakes Steel Corporation

Great Lakes Steel Corporation, subsidiary of National Steel Corporation, has placed in operation its new $25,000,000 mill at Ecorse, Mich., just outside of Detroit. The new plant, largely electrified, represents the last word in modern steel mill construction, and is strategically located both for the movement of raw materials and the shipment of the finished product. The plant has annual capacity of more than 500,000 tons, and comprises an open hearth plant, blooming mills, bar mills, continuous strip mill and two merchant mills.

The Great Lakes plant is located on the Detroit River at Ecorse. The property consists of a rectangular block of 225 acres with a frontage on the Detroit River of about 2,800 feet. The plant is served by the Michigan Central and Detroit, Toledo and Ironton railroads, and water facilities will permit dockage of any lake vessels. Products of the new mill will consist of billets, sheet bars, forging bars, strip, automobile spring steel, rim sections, bumper steel, window sash sections, concrete bars, and small angles and channels.

Construction of the new mill was remarkable for its speed and thoroughness. The property as originally assembled contained three slips. The filling of two of these slips and raising the general elevation for proper sewage system and track facilities was carried out by means of hydraulic sand fill. This method of fill which at times during the construction period amounted to as much as 6,000 cubic yards daily, enabled the construction program to proceed without letup. The first sand fill was made May 25, 1929, excavation began June 12, 1929, and piling was begun June 29, 1929. The most modern methods of piling and concrete construction were used and concrete was first poured August 14, 1929. Extremely heavy foundations are required for mills of this type and at times as much as 1,000 yards of concrete was poured daily.

The first structural steel was set on October 28, 1929, and almost exactly ten months later, or August 23, 1930, witnessed the first steel production in the new plant, which began limited operation on that date.

The open hearth plant consists of six 150-ton rated capacity open hearth furnaces, housed in a modern steel building 208 feet wide by 770 feet long. The layout is designed to permit of extensions to the open hearth plant as required. The furnaces are of the most modern construction, equipped with waste heat boilers and induced draft fans, each furnace discharging into a steel stack brick lined, 180 feet high. In the design of the furnaces, which are fired with oil, the best practice known to secure efficient operation has been incorporated, particular attention being paid to the design of the flues, the checkers, and the elimination of heat losses wherever possible. The furnaces are designed so they can be fired with hot producer gas if at any time this gas would show more economical production.

The charging equipment consists of two 7½-ton low type floor charging machines and one 125-ton overhead electrical traveling crane. Particular attention was paid to securing the best layout of charging floor for rapid charging of the furnaces.

In the pouring aisle of the open hearth building are two 250-ton steel ladle cranes for handling hot metal from the furnaces to the ingot moulds. These

cranes are of the most modern construction and among the largest of their type in the world.

Hot metal is received at the Great Lakes plant from the blast furnaces of the Hanna Company at Zug Island, less than two miles distant, and conveyed to the open hearth plant over the D. T. & I. tracks by means of 110-ton hot metal mixer type cars. Diesel electric locomotives of 70-ton capacity are used for transporting the hot metal.

From the hot metal or "Thermos" cars the metal is transferred into 75-ton ladles, weighed and charged into the open hearth furnaces as required. The use of hot metal effects saving in fuel and time with resultant economies in production costs.

In the north end of the open hearth plant building is located the auxiliary boiler house, consisting of oil fired boilers. The steam requirements for the plant due to the extensive electrification of all equipment, under normal conditions, will be easily cared for by the waste heat boilers from the open hearth, so that the boiler house becomes in effect a reserve unit.

Parallel and adjacent to the open hearth building is a stock house 110 feet wide by 600 feet long. It is served by two 15-ton overhead electric traveling cranes. The stock house is entirely covered so that the severe Detroit winters will not interfere with the regular operation of preparing the charge for the open hearth.

Adjacent to the pouring aisle of the open hearth plant is the mould yard which is a substantial steel frame covered construction 110 feet wide by 330 feet long, served by one 15-ton overhead electric traveling crane.

East of it in line with the mould yard is the stripper building, 54 feet wide by 150 feet long, served by a 200-ton electric ingot stripper crane. This arrangement of stock house, open hearth building, pouring aisle, stripper building and mould yard has been designed for continuous flow of material with a minimum of handling. In the arrangement of tracks, particular attention has been paid to transportation costs.

West of the stripper building and parallel to the Detroit River are located the soaking pit and gas producer building. The hot ingots leave the stripper building and pass directly to the soaking pit building where they are charged preparatory to rolling.

There are four 4-hole soaking pits of the regenerative type installed in a building 113 feet wide by 275 feet long. These pits are served by two 7½-ton pit furnace cranes. The pits are fired with hot producer gas and are designed with particular attention to low fuel cost and maintenance. The pits are equipped with suspended arch type covers, having the drive motors mounted on the cover frames. All controls for the pits are concentrated on one control platform which extends the length of the building.

Hot producer gas is furnished the pit furnaces by three fully automatic producers housed in a building 23 feet wide by 54 feet long. At the south end of this building is a runway 22 feet wide by 72 feet long over the coal and ash handling pits. The producers are served by one 5-ton overhead electric traveling crane. Modern coal handling equipment is provided for these gas producers.

At right angle to the pit furnace building and parallel with the open hearth building is the blooming mill building, 95 feet wide by 725 feet long. This building is served by one 50-ton and one 20-ton overhead electric traveling crane. In this building is installed a modern 40-inch blooming mill with the necessary auxiliary tables and manipulators. The blooming mill is driven by a 7000 h.p. motor.

In this same building is located the bar and billet mill consisting of nine 2-High roll stands and two edging stands. These mills are driven by one 4000 h.p., one 5000 h.p. and two 2000 h.p. motors.

Parallel to the billet mill is the continuous strip mill containing the latest design for rolling strip steel. This mill consists of four 2-High, six 4-High and three edging mill stands. It is driven by one 1200 h.p. motor, one 1600 h.p. motor, one 2200 h.p. motor, one 3000 h.p. motor, and six 2000 h.p. motors. The layout of this mill will permit of rolling direct from the blooming mill, or from slabs from the reheating furnaces depending upon operating conditions.

All of the motor equipment for the mills is housed in a brick building parallel to the blooming mill building which is 44 feet wide by 725 feet long. This building is served by one 50-ton overhead electric traveling crane. In addition to the mill motors it houses the necessary generators, switchboard equipment and the service water pump house.

A 30 foot wide by 320 foot long brick leanto building to the motor room houses the oil switches and air compressors. Adjacent to this leanto building is a 19-foot 6-inch by 84-foot 6-inch transformer station.

Between the blooming mill and the strip mill are located two slab heating furnaces, each having a capacity to heat 40 tons of slabs per hour. The mills are complete with all the necessary auxiliary roller tables and drives.

South of and parallel with the blooming mill building is a covered slab yard 109 feet wide by 450 feet long. This building is served by one 15-ton overhead electric traveling crane.

At the end of the blooming mill building, extending westward, are the strip mill finishing building and bar and billet storage yard. In the bar and billet yard at the blooming mill building end are located two cooling beds and bar pilers. This billet yard is 109 feet wide by 475 feet long and is served by one 15-ton overhead electric traveling crane. The arrangement of this building is such that billets can be delivered directly from here to the merchant mills.

Parallel to the bar and billet yard is the strip mill finishing building. This building is 74 feet wide by 500 feet long and is served by one 15-ton overhead electric traveling crane. This building houses the flying shear, the mill runout tables, the strip coilers and the bar pilers.

At the end of the slab yard and parallel with the strip mill building is located the maintenance shop building. This building is 129 feet wide by 300 feet long and is served by one 25-ton and one 5-ton overhead electric traveling crane. In this building are located the roll, machine, electric, blacksmith and structural shops.

In the leanto of this building is located the store room. This building is fully equipped with modern machine tools for the various departments housed therein.

At the end of the maintenance shop building and parallel with the strip mill finishing building is a coil storage building 104 feet wide by 600 feet long. This building is served by two 15-ton overhead electric traveling cranes and will serve as a storage for the coiled and cut-to-length material from the strip mill. In this building are also located the necessary roller levelers, shears and oiling machines for finishing strip steel. About midway in this building is a leanto building for the products from the strip mill.

In the finishing building is located a mormalizing furnace of the most modern design to insure proper heat treatment of the hot rolled strip product.

At the end of the bar and billet storage yard and parallel with the open hearth building is located the No. 1 merchant mill. This building is 114 feet wide by 1050 feet long and has on the northside a finishing building 100 feet wide by 450 feet long. The mill building will be served by one 15-ton and one 10-ton overhead electric traveling crane. The merchant mill will consist of sixteen stands of rolls and will be complete with the necessary heating furnace, roller tables, cooling beds, and auxiliary machinery.

The mills will be driven by one 300 h.p. motor, two 400 h.p. motors, two 500 h.p. motors, two 600 h.p. motors, two 700 h.p. motors, one 1000 h.p. motor and one 1500 h.p. motor. These motors with their necessary generators, transformers and switching equipment will be housed in a brick building inside of the main mill building.

In general the plant is complete with the necessary tracks, scales, sewer system, water, steam, oil, and air lines, and offices conveniently located to house the operating personnel.

At the foot of Tecumseh road and conveniently located to the mills is a 100-foot wide by 75-foot long, two-story brick office for housing the engineering and operating department.

Electrical equipment comprises an integral part of the new plant of the Great Lakes Steel Corporation.

In the open hearth department everything is electrically operated. Motors are used, of course, on the huge hot metal cranes, on the charging machines, on the furnace fans, valves and doors, and on a multitude of other auxiliary equipment. Steel ingots are stripped out of their molds, set in the soaking pits and withdrawn again, all by electric power.

It is in the rolling mill departments, however, that the use of electrical power is the most important and the most spectacular. In the motor room alone there is installed over 40,000 horsepower in main roll drives and if the capacity of the motor generator sets, used to convert the power, is included, this motor room can boast of more than 100,000 horsepower installed within its walls.

A steel ingot weighing several tons and fresh from the soaking pit, is rapidly reduced to blooms or slabs on the 40-inch reversing blooming mill. A 7000 h.p. or 50/120 rpm reversing motor drives this mill and is, itself, furnished with power from a 6000 k.w. flywheel motor generator set. The blooms or slabs are then sheared on an electrically driven slab shear. The latter has no clutches but starts and stops for each cut. It can make as many as 14 cuts per minute.

The blooms, still containing their ingot heat, are passed through the 21-inch continuous sheet bar and billet mill. The first seven stands are driven at a constant speed by one 4000 h.p. and one 5000 h.p. synchronous motor. The last two stands require adjustable speeds, and each of these is driven by a 2000 h.p. 600-volt D.C. motor.

Sheet bars from billets are delivered from this mill at speeds as high as 9000 feet per minute. An electrically driven flying shear, located in front of the finishing stand, cuts the bars "on the fly" into uniform lengths. This imposes rather exacting requirements on the electrical equipment because the needed accuracy of cutting is within one-half of one percent. Besides this, the shear successfully crops the front end of each bar.

The billets or bars of, say, 30 feet, are then carried on a runout table to the bar piler and the cooling bed. The table consists of many rollers, each driven by a small squirrel cage induction motor, built-in inside the roller itself. The speed of the whole table is adjusted simultaneously by varying the frequency of A.C. power furnished these small motors.

Slabs, sheared on the 800-ton shear, instead of going through the 21-inch continuous bar mill, may be reheated in one of two special furnaces and then delivered to the 20-inch strip mill. The latter consists of ten tandem stands, each driven by a separate 600-volt D.C. adjustable speed motor. The total capacity of these motors is 20,000 horsepower. Three 5000 k.w. synchronous motor generators furnish power to this mill and also the finishing stands of the bar mill.

The same piece of metal may be in several of these stands at the same time. Naturally the driving motors should be designed to hold their speed accurately so as to prevent the steel from stretching or excessive looping.

The slab is now reduced to a thin strip. It may be as thin as one-sixteenth of an inch and may be as much as 32 inches wide. It may be delivered from the last stand at a speed as high as 1200 feet per minute. The problem of handling this steel after rolling is also solved, to a great extent, electrically.

The strip may be cut again "on the fly" to commercial lengths with an accuracy of 1/16-inch on, say, an eight or ten foot length. To obtain such precision, the flying shear is driven by a 125 h.p. synchronous motor, furnished with power from a synchronous generator. The latter is connected to the 2000 h.p. D.C. motor driving the stands. This provides a truly "synchronous tie" between the mill and the shear, without which such accurate shearing would be hardly possible.

Or, the strip may not be sheared but may be coiled. If such material is desired, the strip passes from the mill over a long runout table, also consisting of individually driven motor rollers, to two strip coilers. These interesting machines are also equipped with electric motors, built-in integrally with the coilers themselves.

The main roll drives spectacular as they are in size and capacity, are closely seconded in importance by the large army of auxiliary motors. These sturdy machines, as rugged as their name "mill type" implies, are scattered all over the plant. More than 300 of them are driving heavy mill tables, screw-

downs, shears, transfers, cranes and what not. Metal clad throughout they defy the heat, water, dirt and scale of the steel plant.

Where is the electric power derived? The Detroit Edison Company brings it into the plant at 24,000 volts and steps it down to 6600 volts through three 10,000 k.v.a. transformers. The 6600 volt power is then distributed through a truck type switch gear over the plant.

Three 4000 h.p. motors are used to drive the pumps which furnish the water to the entire plant. Three other 600 h.p. motors are used to drive the high pressure hydraulic pumps for the scale-breaking sprays.

A visit to the main motor room is both interesting and instructive. The equipment is arranged conveniently, with ample clearance and yet without waste of space. The heavy D.C. copper and switch gear is located in the roomy cellar, cutting down the length of runs. All machines are ventilated with filtered air, while the heated air discharged by the machines is thrown out of the room by the machines themselves. This arrangement keeps the electrical equipment and the room clean and the room temperature comfortable, both for the machines and the operators. A natural desire on the part of the operators to keep in good shape the equipment, installed with due care and under favorable conditions, will further assist in keeping the cost of maintenance and repairs at a low figure. Thus a well designed motor room in a steel mill, as in other industries, is not a luxury but a prudenet and highly profitable investment.

The entire arrangement of the plant is such that future extensions can be made with a minimum interference with operations.

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*Transportation within the Steel Plant**

By DAVID M. PETTY†

EDITOR'S NOTE:—Mr. D. M. Petty, Superintendent of Service Division of Bethlehem Steel Co. at Bethlehem, Pa., is a Past President of the Association of Iron and Steel Electrical Engineers. He has performed a most valuable service to the Iron and Steel Industry by preparing and presenting before the American Iron and Steel Institute on October 24th, 1930, a paper covering historical facts of the Iron and Steel Industry, transportation problems and estimated transportation costs. The Association of Iron and Steel Electrical Engineers congratulate Mr. Petty on his paper which reflects his personal thoroughness, unlimited patience and painstaking care.

In this discussion, transportation will be treated in its broadest term to include the moving of anything and everything about the plant. Transportation in the mines and from the mines to the plant, or from the plant to consumer, however, will be considered as outside the scope of this discussion. Those things which are moved from one place to another in the operation of an iron or steel plant, can be divided into two general classifications; viz: energy and materials. Transportation, or as it is generally termed "transmission," of energy about the plant, may be effected by means of water, steam, compressed air, mechanical motion, or electricity. The materials to be transported about the plant include fuel in its various forms, such as gas, oil, tar, coke and coal; ore, flux, scrap iron and steel, pig iron, both solid and molten; steel in its various forms, such as ingots, castings, rolled materials, etc.; also iron castings, ferro-alloys and the various miscellaneous supplies, including refractory materials, that are required in the operation of a steel plant.

While the history of the steel industry is essentially a history of metallurgical and manufacturing processes, the influence of transportation on its development cannot be overlooked. The pioneers quickly recognized it as a major factor touching every element in the economical manufacture of steel. Thus we find transportation marching side by side with the advancement of the industry, from crude rule of thumb to present efficient methods.

As long as man or beast was the only source of energy for transportation or manufacture of iron and steel, the size of the various operating units was, of necessity, small. In the early Christian era and perhaps before, the small catalan forge was blown by a bellows operated by a man. The iron ore and charcoal were placed in the furnace by hand; the product was removed by hand and finished by hand hammering. The first blast furnaces were also blown by hand bellows or foot blast. They were located near the source of iron ore, because the ore was the heaviest of the raw materials, and transportation facilities were extremely crude. The fuel, consisting of charcoal, was made from the forests surrounding the mine and the product was carried to market either by man or beast.

In the fourteenth century, the waterfall became a source of energy for the blast furnace as well as for the forge, but because this energy could not be transmitted to the furnace if located at the ore mine, the furnace was moved to the water power site. The bellows was operated by knobs on the axle of the water wheel and a similar device operated the "tilting hammer." The "mill pond" of our time was known in England at this time as the "hammer pond." The fuel for the blast furnaces continued to come from the forests and considerable anxiety was expressed about their depletion, so that, in 1558, laws were passed forbidding the cutting of timber in certain parts of England for conversion into charcoal "for the making of iron." The blast furnace, being fixed in location by the waterfalls, soon had to transport its supply of charcoal from great distances and in many cases, lack of transportation facilities caused the furnace to be moved to a new location where there was water power as well as forests.

In 1735, the introduction of the use of coke in the

*Presented before American Iron and Steel Institute at New York, October 24, 1930.

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blast furnace in England fixed the supply of fuel geographically, and, as a consequence, the iron industry soon located itself at water power sites, which were also convenient to the ore and coal mines. Roads were built and various forms of wagons developed by means of which both the coke and ore were hauled to the furnace.

About 1769, James Watt made certain improvements in the steam engine, which, when coupled to the "cast iron bellows," invented by John Smeaton in 1760, began to release the blast furnace from the water power and at the same time made a greater volume of blast available which in turn made greater production possible. One reason the steam engine was superior to the water wheel as a source of energy for driving the blowing tub was that its motion was rectilinear and reciprocating while that of the water wheel was circular and continuous. The crank as a means of transforming circular to rectilinear motion and vice versa, was not invented until 1774. The water wheel, however, remained a satisfactory and cheap source of energy for the "tilt" hammer as well as for the rolling mill (which was invented by Henry Cort in 1783), because its energy could be transmitted by means of shafting and gears and utilized in its circular and continuous form.

The iron and steel industry grew rapidly and with its growth the problem of transportation demanded the handling of materials in larger quantities than a man or a horse could carry or than horses could pull on a wagon rolling on a dirt road, so that so-called "corduroy roads" were constructed, by laying timbers crosswise on the road. Rolling friction on this type of road was very high, so that in 1671, roads equipped with wooden rails were put into service. Later, on this track, strips of iron were laid so as to further decrease the friction of the wheels and also materially increase the life of the road. In 1767 solid cast iron rails were introduced in England to replace the wooden rails, largely on account of the growing scarcity of timber. In 1818 the first rail road was installed in an iron or steel plant in America at Bear Creek furnace, Armstrong County, Pa.

In 1794 the first steam engine was built in America and the census of 1820 mentions two iron works using steam engines. In 1828, Neilson of Scotland invented the hot blast, so that for the first time it became necessary to conduct the blast air in other than the shortest route from the blowing tub to the furnace and in 1840, at the Elizabeth furnace, Blair County, Pa., gas from the tunnel head was conducted to boilers for the purpose of making steam and shortly after this furnace gas was used to heat the hot blast which had been previously heated by burning virgin fuel. Anthracite coal was first used in blast furnaces in England in 1836 and in America in 1839. About 1847 the Lehigh Crane Iron Works, Lehigh County, Pa., used a steam locomotive for hauling ore from its nearby mines as well as for hauling other material about the plant. This appears to be the first installation of a steam locomotive in the iron and steel industry in America, if not in the world.

In the early days of the industry, blast furnaces were usually constructed in valleys not only to use the water power, but also in order to use the adjacent hills as an approachment for transporting the raw materials to the top of the furnaces. The development of the steam engine, however, eliminated this problem and as furnaces were built taller, as well as larger, inclined planes and vertical lifts came into use, the energy of the steam engines sometimes being transmitted to the lift by means of hydraulic pressure and later by hoisting engines, utilizing rope.

The steam locomotive and railway cars were being rapidly developed at this time so that a better roadbed and rails were demanded in order to successfully handle the increasingly heavy traffic. The first T-rails rolled in America were rolled at the Montour Rolling Mills, Danville, Pa., in October, 1845, and from this beginning, wrought iron rails and later bessemer steel rails, rapidly became standard for railways.

The manufacture of steel was limited to small size units until the introduction of the bessemer process in 1858, so that the problems of transportation could be handled in the same manner as they had been handled in the blast furnace departments. The bessemer converter, however, made it necessary to handle larger quantities of molten iron as well as steel and to transfer it from one place to another. The earlier installations transported the molten iron from the cupola to the bessemer converter by means of a suspended trough and steel was cast into the ingot moulds direct from the converter. Later ladles, mounted on a carriage, were used to transport the iron from the cupola to the converter as well as from the converter to the casting pit. Following this the molten pig iron was transported from the blast furnace to a mixer and then to the converter by means of ladles.

In 1862 the first open-hearth steel was made in England, and in 1868 in America at the New Jersey Steel and Iron Co., Trenton, N. J.

The only overhead means of handling the ladles at this time was the jib crane, mounted on a building column at one side of the building or on a column erected in the shop and help at the top by the roof trusses.

It was by means of these cranes that the ingot moulds were stripped from the ingots and the ingots lifted out of the casting pit for loading on cars to be moved to the heating furnaces for rolling.

These early cranes obtained their power from hydraulic cylinders, but later steam engines were applied direct to the hoisting gear and to the other motions.

In 1882 the first traveling cranes were introduced into the steel industry. These were driven by both steam and compressed air engines, as well as by means of square shafting and endless ropes which were carried parallel to the crane runway as well as the bridge girders.

Light weight narrow gauge tracks were used about the plant for the purpose of hauling heavy material from one department to another and especially for hauling the ingots from the bessemer and open-hearth departments to the rolling mills. In 1891, as far as it can be determined, the first ingots were cast on an ingot buggy at the Sparrows Point plant of the Maryland Steel Company. This was a radical step in advance in the transporting of hot ingots from the casting department to the rolling mills and was the beginning of the present-day practice of casting ingots vertically in iron moulds on

buggies, moving these to the stripper and from there to the soaking pits.

As long as the product of the bessemer converter and open-hearth furnace was rolled into rails or bars, or forged into small pieces, there was no demand for any type of machinery with which to handle heavy loads. The largest bessemer converter of this time (1886) was ten tons and this was also the size of the early open-hearth furnaces.

In 1887, however, the Admiralty in England and the Navy Department in the United States began to ask for larger forgings to be used in the manufacture of guns, France having already made some progress along this line. This demand was followed in a short time for still heavier pieces of forged steel armor plate. The first armor plate forged in the United States was forged at the Bethlehem Iron Company plant in 1888 on a 35" Witworth press. In order to handle the ingots for these heavier pieces, a 75-ton crane was erected in the open-hearth plant of the Bethlehem Iron Company in 1887. This crane as well as a great many others similar to it, was driven by means of compressed air engines.

Great strides had been made in the art of transmitting energy by means of steam, water and air under pressure, but when the electric motor made its appearance, in 1880, electricity became the potential successor of all these agencies as the premier transporter of energy. The first successful street cars were operated in 1888 and this same year finds the first electric motor introduced into the steel industry. In 1890 the first motor was installed on a traveling crane.

In 1905, the first electric motor was installed to drive a rolling mill at the Edgar Thomson plant, Carnegie Steel Company, Pittsburgh. This was a pioneer installation indeed and was not closely followed by other mills, since the power required to drive the mills was about equal to the capacity of the largest engines and generators available at that time. However, the ease and efficiency with which energy could be transmitted by means of electricity and transformed into mechanical power, made possible many of the mechanical devices in the early days, as is the case today.

Electric Power Transmission

While a discussion of power generation in the steel plant is without the scope of this paper, the transmission of energy for power purposes is one of the major parts of the transportation problem in its broadest phases. Electricity is now recognized as the most convenient, as well as the most efficient method of transmitting energy and is therefore almost universally used. The electric generator may be driven either by steam turbines or gas engines. In the case of steam turbines, the units are large and few in number as compared to gas engines, but the thermal efficiency of the latter will be somewhat higher than the former. Just which type of prime mover is used will depend on many factors, such as the availability of a satisfactory amount of condensing water, the B.t.u. balance of the plant gases and waste heat, etc. In the case of a plant situated in a locality where coke oven gas can be sold to the surrounding community for domestic or industrial purposes, steam turbines will probably offer some advantages over gas engines, inasmuch as all of the final remainder of the blast furnace gas, after all the metallurgical heating requirements have been met, could be burned under boilers and any deficiency in this supply made up with powdered coal or other available fuel. Such fuel will be admitted to the boilers automatically whenever a deficiency in the gas supply occurs, the deficiency manifesting itself by a falling off in pressure of the gas or steam. This method of operation will probably be better than the now more or less common practice of making up the deficiency at the boilers by reducing the gas consumption in the blast furnace stoves, as it is very desirable in the interest of maximum operating efficiency that the gas pressure as well as the supply at the stoves remain constant.

The character of electricity to be used is very important and it is to be regretted that the steel industry in America is more or less committed to three-phase, 25-cycle current, whereas the trend of all public utility super power systems is towards three-phase, 60-cycle. At the present time, in practically all locations, a new steel plant being designed today would use three-phase, 60-cycle electric power, not only because it would facilitate an interchange power connection with super power public utility companies, but also because most of the electrical apparatus would cost from 10 to 25% less than in the case of 25-cycles, and a much wider choice of motor speeds are available.

At the present time, the standard voltage for transmission in steel plants is 6600. This particular voltage offers the advantage that generating apparatus, as well as motors as small as 150 H.P., can be conveniently built for this potential, so that a high percentage of the total power can be generated and used at the same voltage, thereby avoiding the first cost as well as the operating losses of transformers.

The choice between an overhead and underground transmission system depends upon many factors. Where the amount of power is not excessive and distances are reasonable, lead covered three-wire cables drawn into suitable underground ducts will prove to be a very satisfactory transmission system. It has two very important points in its favor: first, it is not subjected to overpotentials, due to lightning; second, the conducting wires being very close together in a lead cover, offer very good voltage regulation. Such a system, however, is very expensive and has two disadvantages; viz., that it cannot carry sustained overload without doing serious permanent damage to the insulation of the cable, and there is a definite limit to the size of cable that can be manufactured or installed, so that additions to the plant must necessarily mean additional cables. Unless an ample number of spare ducts are installed at the time of the original installation, such a transmission system is not flexible from the standpoint of expansion.

Overhead transmission systems can be successfully built and operated even in localities where lightning disturbances are severe and frequent. A well grounded overhead ground wire system, together with a liberal installation of lightning arresters of suitable type, will reduce over-potential troubles to a very low minimum, so that transmis-

sion line failures will occur only in the event of a direct hit and this is rather infrequent around a steel plant where there are a great many high steel stacks which make admirable lightning rods and materially assist in reducing the number of direct hits. The use of lightning arresters installed close to the important motors as well as generators will practically preclude failure of such apparatus by lightning.

For A.C. motors smaller than 150 H.P., a voltage lower than 6600 is required and a choice must be made between one of the four standard voltages now in common use; viz., 550, 440, 220 and 110 volts. With 220 volts, energy can be successfully transmitted approximately 1000 ft. with an energy loss of not over 10%, working the copper conductors at about their maximum carrying capacity, so that this has been adopted as a more or less standard voltage for small motors in the steel industry. It also offers the advantage that direct current is conveniently available at this same voltage, so that a modern plant can be laid out with only two standard operating voltages, 6600 and 220, with possibly a third higher voltage for transmission purposes only.

In the direct transmitting systems in the steel industry, 220 volts is standard and little need be said except to point out the advantage of grounding the negative side of such transmitting systems and installing only a positive contact conductor along the runway for traveling cranes using the track as the negative return. There appear to be no difficulties in utilizing this system provided ample copper conductors are installed on the negative side from the point of consumption back to the negative bus in the sub-station and that all proper precautions are taken to prevent stray currents from following pipe lines and thereby causing electrolytic corrosion. Operating the direct current systems of the steel plant with the negative side grounded, offers a growing possibility in the use of third rails and electric locomotives to replace some, if not all, other locomotives. This point will be discussed more fully under the subject of locomotives. It should be noted that the third rail can be connected to the most convenient of the plant feeders by means of relatively high-speed circuit breakers. This will avoid causing power interruptions in the plant department whenever there is trouble on the third rail system, since the feeder circuit breaker in the sub-station will have a slower operating relay than the third rail breaker.

Railway Transportation

The greatest problem of transportation about the steel plant and the one that is ordinarily considered as the only transportation problem is that of the railway serving the plant. It will be considered as outside the scope of this paper, however, to consider the various legal and operating regulations of terminal railroads, so only the mechanical and engineering phases of this subject will be discussed.

Trunk line railroads developed earlier and much more rapidly than the steel plants and some of the car equipment which had proven satisfactory in general service and was transplanted from the trunk lines into steel plant service did not prove very successful. In general, it is a far cry from ordinary materials which are handled on a gondola car to the hot slag and refuse which is loaded into such cars in the open-hearth departments. Today, however, much heavier cars have been built for steel mill service and the requirements of the steel industry are much better met by the builders of equipment than was the case in the past. The use of double or insulated bottoms for handling hot material in the side dump refuse cars is a notable step in advance as compared to the car as used in standard railroad service. The handling of hot metal from the blast furnace to the open-hearth mixers is also a special problem which has been solved by the large mixer-type ladle car which carries 3 to 4 times as much hot metal per unit as the old open-top ladle mounted on wheels. Due to the fact that the mixer-type ladle car has a small opening through which the molten metal is poured, there is a much slower loss of heat, consequently much less skulling than with the so-called open-top ladles, so this unit not only has reduced the cost of transportation, but also the cost of repairs to the ladles.

In taking the slag away from the blast furnace, where it is to go over a dump or to a slag preparation plant, the slag is cast directly into thimble shaped pots which are mounted on a suitable car. These cars are arranged so that by means of a steam or air cylinder or electric motor, the pots can be turned to an angle of slightly more than 90 degrees, thereby dumping out the slag which may be in a partially solidified form. The side walls of these pots must be smooth and straight so that the skulls which are formed in the bottoms and on the sides will not adhere, but will dump immediately. These cars usually carry two such pots, but if the local conditions warrant more pots could possibly be mounted on a single car. Electric motors appear to be the preferable type of power for dumping these cars, because it is easy to transmit the necessary energy to the point where these cars will be dumped and it will not be necessary for the locomotives to remain while the dumping process is taking place.

Similar cars are used for hauling the slag pots away from the open-hearth furnaces. However, in this case, the pots do not remain on the car while being loaded, but are placed adjacent to the open-hearth furnace so as to catch as much as possible of the overflowing slag, not only from the furnace, but also from the ladle when the steel is being tapped. These pots, when full, are transferred to the car, which is moved to a suitable location where it is dumped into a pit. Out of this pit the steel, which settled to the bottom of the pot and solidified into a so-called button, is recovered by means of lifting magnets, while the slag which may contain a certain amount of alloys is suitably broken and sent to the blast furnaces where it replaces a certain amount of limestone as flux. There appears to be no reason why the cars for handling the blast furnace slag cannot be a duplicate of the cars which handle the open-hearth slag. The pots in each of these cases, however, may have to be designed differently in order to best handle the two different types of slag.

Refuse from the different departments can best be handled in side dump cars which are usually dumped either by means of air or steam cylinders, but could possibly be better dumped by means of

an electric motor. At the present time most of the dumping is done by means of air cylinders and the locomotive remains with the train until all cars are dumped. Since this refuse will dump freely and a long string of cars cannot be handled on the average refuse dump track, there is not much lost time for the locomotive in this process. There are certain classes of refuse which should possibly pass through a reclaiming plant which will reclaim and prepare suitable brick and sand for further use in the various departments. This, however, will not materially change the transportation problem of refuse from that which exists today.

In moving the ingots from the open-hearth furnace to the strippers and to the soaking pits, a choice must be made between standard gauge and narrow gauge track systems. The three-foot gauge is amply wide for casting any size ingots that will probably ever be required in the rolling mills and it offers the advantage that in this part of the transportation system, curves of short radius can be successfully negotiated. The locomotives are more compact and less expensive than the small size standard gauge which could do this work. To offset these advantages, casting ingots on standard gauge ingot buggies would keep the transportation system uniform and would enable locomotives as well as cars to be used throughout the other parts of the plant without running additional three-rail or narrow gauge tracks. Also the standard gauge being wider, uneven spots in the track system are less likely to cause an overturning of the load. In the ingot mould storage yard, however, the curves and tracks would occupy considerably more space than with the narrow gauge. In the case of both the narrow gauge and standard gauge ingot buggies, roller bearings are almost universally used in preference to the standard brass M. C. B. bearings. This is due not only to their lower friction and maintenance cost, but also on account of the difficulties involved with the M. C. B. bearings in places where hot metal is liable to be splashed into the bearing and ignite the oil soaked waste or grease used for lubrication, whereas the roller bearing is entirely enclosed.

On the cars carrying the charging boxes at the open-hearth department, the advantages of standardization on broad gauge equipment are more evident because the cars carrying such boxes can be placed at the various points where mill scrap is made, such as at the crop shears, and the scrap charged directly into the boxes rather than being loaded into standard gauge cars and then transferred to the charging boxes at the open-hearth stockyard. The charging box, however, being approximately the same length as the width of the standard gauge car, determines the spacing of tracks in the openhearth stockyards, so that no ground space can be saved by using narrow gauge tracks.

The choice between standard and narrow gauge track system for the ingot buggy and other service around the steel plant will have to be finally decided after all the local conditions are taken into consideration. If space is at a premium and the plant layout requires many sharp curves, the narrow gauge track system will prove more satisfactory than standard gauge. On the other hand ample space and absence of sharp curves are to be desired and if they are both possible the standard gauge track system should be used.

At the present time the locomotive used for shifting in the steel plants is the same as has been used by the trunk line railroads for many years, that is, a locomotive with relatively high tractive effort compared with its boiler capacity and one arranged with a water tank and tender of smaller capacity than is required on main line freight service. The essentials of a successful yard shifting locomotive is that it should be able to exert a high tractive effort for a short length of time in order to quickly accelerate its load, because shifting service is primarily one of acceleration and deceleration. The steam locomotive with large cylinders compared to its boiler, meets this requirement fairly well, but this irregular load on the boiler very materially lowers its efficiency, and a considerable amount of smoke as well as cinder is blown through the locomotive stack. The electric locomotive admirably fulfills this requirement because of the ability to operate motors in series for high tractive effort, and in parallel when higher speeds and less tractive effort is required. Owing to the difficulty of providing a contact system, the electric locomotive is not generally looked upon as a suitable shifting unit, one of the difficulties being that an overhead electric contact system interferes very materially with the operation of locomotive cranes throughout the plant, and the third rail contact system does not lend itself readily to frequent cross-overs and switches. The difficulties which these two contact systems seem to impose have made the progress of electric locomotives in the steel plant rather difficult. At the present time there is considerable discussion of the internal combustion engine which, coupled to an electric generator and placed on the locomotive, attempts to overcome the difficulties imposed by the contact systems in making yard shifting electric locomotives available, and considerable progress is now being made.

The internal combustion engine, however, is essentially a constant speed, constant load engine and does not lend itself readily to frequent acceleration such as is met with in yard shifting service. Its efficiency is also materially lowered whenever its load factor is low. The load factor of an average yard shifting locomotive does not exceed 15% and will more likely be in the order of 10% which means that a 400 H.P. engine in shifting service will have an average load of approximately 40 H.P. In order to meet the qualification that a shifting locomotive should be capable of exerting high tractive effort for short intervals of time, it would appear that some kind of a fly wheel should be installed on the locomotive to supply high peaks for short periods of time and thus average out the load on the engine and thereby improve its load factor and its efficiency.

The storage battery appears to meet this qualification fairly well. That is, a storage battery applied to a locomotive, which will also have an internal combustion engine connected to a generator which operates in conjunction with the storage battery, should make an ideal shifting engine. A storage battery is capable of delivering large volumes of energy for short intervals of time, so that an engine running at constant speed and essentially constant

load delivering this energy to the storage battery, which in turn could deliver it in irregular quantities to the motors, should work out very satisfactorily. A locomotive requiring 600 H.P. should be able to operate very satisfactorily with approximately a 200 H.P. engine with a storage battery capable of delivering about 400 H.P. at a high rate of discharge. The points yet to be determined exactly are the average cost of battery renewals and also the average cost of repairs to the engine. However, it is quite certain that the repairs to such an engine will not be as great as the repairs to an engine which is subjected to the wide ranges of load which occur on a unit which does not have a storage battery. With this type of locomotive, either with or without a battery, it should also be noted that it is entirely possible to install a third rail or overhead contact system in certain locations throughout the plant, especially where there may be long heavy pulls, so that energy could be taken from the plant electrical system at these points and supplement or replace the power from the engine and battery. If all the ruling grades are electrified, the size of the engine and battery could be reduced. A third rail contact system will probably be looked upon with more favor than an overhead system, and can be installed for approximately $2 per running foot of track. Whether or not such a contact system is profitable, depends entirely upon the number of electric locomotives in use and the traffic density on the track at those particular points.

Transmission of Gas

The transmission of blast furnace gas from the furnaces to all parts of the plant can be accomplished in general by one of two methods. First, by using a relatively low pressure and very large pipes and having this pressure supplied almost entirely by the blowing engines, that is, by having a relatively high raw gas pressure; second, by maintaining a relatively low blast furnace gas pressure in the raw gas system of the furnaces, and after cleaning this gas, increasing its pressure to any desired amount by means of boosters, thereby using somewhat smaller pipes from the point of cleaning to the various consuming departments. In the case of the first method, it is obvious that the piping system will cost somewhat more than in the second method. However, in the case of the second method, the cost of boosters and motors is in addition to the cost of piping, and there is a constant running expense due to the power required by the boosters. Should the amount of power required to do this boosting be 1000 k.w. and the power cost $.004 per k.w. hour, this represents a daily expense of $96 or $35,000 per year, so that the somewhat greater first cost of piping of the first method will quite likely be offset by this high operating cost. Transmitting gas of this nature, under a relatively high pressure, however, offers the advantage that the compressing of the gas makes a fairly large storage system of the piping so that in the event of a power interruption of short duration, the gas supply will not be entirely depleted. The low pressure system, of course, having a greater cubical content of the piping system also offers a certain amount of storage capacity, but gas will not flow to the consuming departments unless it is under a certain minimum pressure.

The problem of transmitting coke oven gas is subject to the same general comments as blast furnace gas, but its calorific value being five times as great as blast furnace gas and its specific gravity being lower, the power required to transmit equal volumes is somewhat less and to transmit equal number of B.t.u.'s is somewhat less than one-fifth as much as in the case of blast furnace gas, so that while the problems are similar, they are much easier to handle. In the case of coke oven gas, suitable storage tanks in the form of gas holders can be applied much more easily than to blast furnace gas and prove to be a very satisfactory answer to the problem of constant pressure and irregular production and consumption.

In laying out the iron and steel plant of the future, considerably greater attention will be given to the problem of transmission of plant by-product gases than has been given in the past, but since what will be done depends on so many variable factors, only the high spots have been mentioned in this discussion.

Estimated Transportation Costs

It will facilitate a discussion of transportation costs if a hypothetical plant is assumed and concrete figures used. This hypothetical plant is to be modern in every sense of the word and it is assumed that the various units will be installed to realize all of the best performances that have been made up to this time, so that the net figures used in this discussion are probably better than will be found in any existing plant today, but no better than can be achieved in any plant designed in the light of present day knowledge. For instance, it will be noted that the heat balance, expressed in B.t.u.'s, shows ample fuel in the plant without bringing in anything beyond the coal necessary for the manufacture of the required amount of coke. No effort, however, has been made to point out just how and where the various by-product gases, steam, etc., are to be used, because there are many different ways in which the net result could be obtained.

It is assumed that this plant will ship 3000 tons of heavy and light structural steel shapes each 24 hours. Starting at the by-product coke plant, each day 2820 tons of coal and 2.8 tons of refractories will be received and the following materials moved away: 2000 tons of coke to the blast furnaces; 23,800 gallons of tar to the open-hearth; 36,600,000 cu. ft. of gas to the open-hearth, soaking pits, reheating furnaces and distributing gas company; 80 tons of coke breeze and nut coke to the soaking pits and gas producers; 29 tons of solid and 9800 gallons of liquid by-products to railways for shipment to customers; 2.00 tons of refuse to refuse dump. The transportation expense for these movements will total $350.

This includes the cost of moving the coal from the car dumper on belt conveyors through the various preparation processes, handling the coke with a quenching car and passing it through the cooling and screening processes until it is finally delivered by means of a belt conveyor into a suitable bin located at the top of the blast furnace. This procedure will differ somewhat from that now in usual practice, where the coke is delivered by means of a belt or cars to the regulation blast furnace bins,

and from there, after passing through a larry car, is raised to the top of the furnace by means of a skip hoist, but there would appear to be no insurmountable difficulties in adopting this method and the thought has been expressed that it might be quite a superior method to that now commonly in use. The reasons behind this though many are outside of the scope of this discussion.

Daily at the blast furnaces, the coke will be joined by 4000 tons of ore, 290 tons of limestone, 550 tons of Open Hearth slag and 110 tons of scrap. This material will pass through the car dumper and storage yards, with its complement of ore bridges and transfer cars and finally be delivered to the furnace by a skip hoist; in addition to this material, a daily average of 12 tons of refractories for relining the blast furnaces and stoves as well as for lining spouts, plugging tap hole, etc., and 10 tons of miscellaneous supplies such as tuyeres, cooling plates, repair parts, and slag pots, will be delivered to the blast furnace department by motor truck or in standard gauge box cars and gondola cars. All this will accumulate $495 per day in transportation costs.

From the blast furnace each day 2083 tons of pig iron will be moved to the open-hearth department in mixer type ladle cars and transferred to large hot metal mixers by means of suitable ladles and ladle cranes. 1300 tons of slag will be taken to a slag dump, a commercial slag plant or a cement plant. The type of equipment used in the first two cases will probably be a side dump car carrying two or more thimble shaped pots; in the last case the slag will first pass through a suitable granulating plant and then move to the cement plant in gondola cars. 20 tons of refuse will be hauled in side dump cars to a refuse dump, and 150 tons of flue dust will be hauled to a sintering plant for mixing with fine ores and roll scale or to be sintered alone, depending upon the type of raw materials available. 313,600,000 cu. ft. of blast furnace gas will be cleaned and piped to consuming departments, such as blast furnace stoves, blast furnace gas engine driven blowing engines, electric power gas engines, steam boilers, open-hearth furnaces, soaking pits, heating furnaces, ignition furnaces at the sintering plant and to the coke ovens. Moving all this material away from the blast furnaces will accumulate a total transportation cost of $285 per day.

From the hot metal mixers at the open-hearth 2083 tons of pig iron will be transferred by means of overhead traveling cranes and ladle cars to the open-hearth furnaces; 165 tons of mould and pit scrap will come from a scrap breaking plant on gondola cars to the open-hearth stockyards and there transferred to charging boxes mounted on cars; 715 tons of home scrap will come from the mills in charging boxes. 692 tons of steel scrap will come from a scrap preparing plant adjacent to the open-hearth stockyard in charging boxes ready to go into the furnaces. This scrap has arrived from various sources outside of the plant in the unprepared condition on cars according to the class of material. 300 tons of scrap will come from sources outside of the plant, but in a condition to be directly transferred from gondola cars by lifting magnets into charging boxes carried on cars; 349 tons of alloys and ore will come to the stockyards in cars, some of the ore will pass through suitable bins and be fed directly into charging boxes mounted on their respective cars. Another portion of the ore, as well as the alloys, will be unloaded in bins adjacent to the open-hearth furnace floor and fed into the furnace as required. 375 tons of limestone will come to the open-hearth stockyard bins in bottom dump cars and be unloaded directly into charging boxes mounted on their cars. 388 tons of refractories will be received, the dolomite in gondola cars and brick in suitable box cars. To move all these materials into the furnaces, the transportation charges will be $478 per day.

These total costs include not only the item commonly shown on most coke oven, blast furnace and open-hearth cost sheets as transportation, but also will include a considerable proportion, if not all, of the expense known as handling raw materials, stocking, and charging, depending upon the manner in which the cost sheets are prepared. For the purpose of this discussion, all handling of the materials up to and including the charging machines, has been considered as a transportation cost.

From the open-hearth furnace 3750 tons of steel per day will be taken in suitable ladles handled by overhead traveling cranes and cast into ingot moulds carried on cars; moved to the stripper where the moulds will be removed and then transported on the same cars to the soaking pits, where a pit crane will charge them into the soaking pit furnaces. 100 tons of pit scrap will be moved on gondola cars to the scrap breaking plant for preparation. 100 tons of refuse will be carried in side-dump cars from the open-hearth to a refuse dump. However, at the time when the furnaces are being rebuilt, this refuse brick will pass through a reclaiming plant which will reclaim a certain amount of this material for further use as a refractory material; 565 tons of slag will be moved in side-dump slag cars similar to those in the blast furnace department and dumped into a pit where the stray steel will be picked out of the slag by lifting magnets and returned to the open-hearth, and the slag suitably prepared and removed to the blast furnace department; 4770 million B.t.u.'s in the form of steam will be reclaimed from the total number of B.t.u. passing out of the furnaces. This is transmitted into the steam system of the plant and used according to the layout of the plant, either directly in steam engines driving mills or in steam turbines generating electric power.

Moving all this material away from the open-hearth department will involve a total transportation cost of $163 per day.

After placing the ingots in the soaking pits and bringing them to the proper uniform heat, they will be withdrawn from the pits by the same crane which charged them and placed upon a carriage or roller tables which will convey them directly to the blooming mills. From this point the ingots will pass through the various mills depending upon the product to be manufactured until finally discharged from a straightening machine. In the case of small shapes, the billets will require shearing and reheating, but all of these movements will be accomplished by means of roller tables, and other suitable machinery in connection with the furnaces and mills and will not be considered as a part of the transportation system and therefore not included as a part of the transportation costs. However, after leaving the

straightening machine, the material will pass by means of roller tables into a storage yard where it will be stored according to sizes, later cut to lengths according to orders, and placed on cars for shipment to customers.

In the storage yard there will be two movements: lengthwise of the runways or buildings, the material will be carried by a double trolley overhead traveling crane. Across the runways or buildings, the material will move on roller tables, not only in each bay, but also from bay to bay. By means of these two motions, material from any part of the yard will be assembled into any one location for loading on cars. Cars will be spotted in the yard according to the length of the material to be loaded. Material longer than 65 ft. being loaded either as an overhanging load on one car with an empty adjacent, or as a double load being carried on two different cars, so that a certain amount of yard shifting will be necessary in order to place the single load and double load cars into the yard at the proper points. After the loading is completed, the cars will be shifted over track scales, weighed and of the 3750 tons of ingots delivered to the mills, 3000 tons of finished products will be delivered to the railroads for shipment to customers.

There will also be delivered to the mills by truck and on cars certain mechanical supplies and spare parts. Also rolls will be moved from the mill to the roll turning department and back after having been redressed, and 75 tons of roll scale will be delivered to a sintering plant. Each day the total transportation expense for moving this material will amount to $437.

600,000 k.w. hours of electric power will be delivered to the coke ovens, blast furnaces, open-hearths, mills and shops. Including the transformation losses for the low tension alternating current and the conversion losses on the direct current, as well as the transmission losses for both the high tension and low tension current, it will cost approximately $200 per day to deliver this energy from the power house to the consuming units.

There will be transportation charges on all the water used in the plant. It may be said that practically the entire cost of water is transportation. This cost will vary within wide limits, depending upon the geographical location of the plant with reference to the point of the water supply. If it happens that this water supply comes from a source with a considerably greater elevation than that of the plant, the transportation charges would be very low, inasmuch as there might be sufficient head to cause all the flow necessary. On the other hand, if the water supply is at a lower elevation than that at which it was found desirable to locate the plant, all the water would have to be pumped against a static as well as a friction head. For this reason, a more lengthy discussion on the subject of transmission of water will not be made and this item of transportation cost is omitted.

Compressed air will be used throughout the various departments of the plant for such purposes as chipping, riveting, reaming, etc. The overall efficiency of a compressed air system for transmitting power is very low compared to an electrical system, but compressed air tools are an essential item in the list of small tools of the plant and approximately 2 million cu. ft. of air will be used per day, the transmission cost of which will be approximately $4.00 per day.

Steam will be required in the by-product departments of the coke plant, but in the other manufacturing departments none will be required. Heating in the offices and shops will be obtained from coke oven gas. Steam used for generating power will be transmitted a very short distance except that which is generated in the waste heat boilers of the open-hearth and other furnaces and this will be conducted by straight lines well insulated so the transmission losses will be low.

10,800 million B.t.u.'s in steam will be required for generating power and 912 million for the by-product department of the coke oven. There will also be at least one steam driven standby pump in the main water supply pumping station, which will receive its steam from the main steam station if sufficientiy near at hand, but since this line will be used for emergency only, the losses will be low. The total transmission cost for steam will be approximately $35 per day.

The total estimated daily cost of transportation in this hypothetical plant is $2447 or approximately $.82 per ton of finished product shipped. This includes the moving of energy in the form of electricity, fuel in the form of gas as well as the various raw materials which are hauled on cars. It is also based on the assumption that all incoming material is received on cars. If the ore and coal should arrive by water there would be a slight change in some of the costs for stocking as well as for car dumping and shifting, but the cost of dumping cars will about offset taking the ore out of boats. The transportation costs accumulated before the material arrives at the plant are outside the scope of this discussion.

In arriving at these total costs, no investment charges have been included because construction costs would vary widely with the location of the plant and the cost of capital would vary with the condition of the money markets.

EXECUTIVES AND PERSONNEL OF THE ELECTRICAL DEPARTMENT OF THE A. M. BYERS COMPANY PLANT, AMBRIDGE, PA.

Top Row, Left to Right—J. Taylor, J. Gould, C. Swartz, L. Zettle, J. Ertle, L. Nugent, F. O. Holler, W. Christopher, J. Boggs, E. Bermer, W. Brooks, P. Gvoych, P. Paletti, S. Kelly.

Next Top Row, Left to Right—H. Young, A. S. Pascoe, A. J. Cox, A. S. Welsh, G. Chapin, G. McCloy, H. Allen, J. B. Sullivan, E. Kelly, C. S. Harris, G. Jackson, T. Frazier, F. Frazier, W. Smith, F. Scoff.

Next Bottom Row, Left to Right—C. Metzgar, R. Gillman, R. Johnson, W. Branyan, R. Gilpin, C. W. Edwards, R. R. Shepherd, G. E. Ramsey, A. Vodenicher, H. Morgan, L. Miller, J. Armitate.

Bottom Row, Left to Right—J. Galbreath, J. Pander, R. May, F. Graham, A. Zanker, C. A. Miller.

Elements of Lubrication Practice *

Points Governing Selection

To select the proper lubricant for a given bearing application requires consideration of the following factors: the size of the bearing; the speed of the shaft; the bearing pressure; the bearing temperature during operation; the film-forming conditions, such as the bearing clearance and the method of lubricant supply. A further factor is impurities, such as water, dust, and the like.

Oils and Greases

There are two general types of lubricants in use —oils and greases—and each type has its legitimate application, which depends on operating conditions, design of bearings, speed, pressures, and other special conditions. Lubricating oils of varying degrees of viscosity, cold test, flash point, and other physical and chemical characteristics are products in the refining process of mineral crude oil or petroleum. When certain saponified fats, known as "soaps" are incorporated in lubricating oil, the resulting product is grease.

The factors affecting proper lubrication as discussed in this article, apply to both oils and greases. In succeeding articles the field of application of oil and grease will be discussed in further detail.

Bearing Size

Bearings are classed as follows: small, medium, or large size: **small size,** referring to those up to one inch in diameter; **medium size,** from one to three inches shaft-diameter, and **large size,** greater than three inches shaft-diameter.

The larger the bearing, the greater is the area over which the lubricant film must be spread; thus requiring more attention to lubricant distribution.

Speed of the Shaft

The speed of the shaft may be classed as low **speed**—below 50 r.p.m.; **medium speed**—from 50 to 300 r.p.m.; and **high speed**—over 300 r.p.m.

The speed of rotation has an influence on the formation and maintenance of the lubricant film. High speed produces a strong driving force to carry the lubricant into the area of greatest pressure, and maintains the supporting lubricant film against the load. Low speed fails to develop the necessary pressure in the film, unless lubricant of sufficient body and adhesiveness is selected.

For equal speeds (r.p.m.), the larger the diameter of the shaft, the higher the surface speed and, therefore, the greater is the film-forming tendency.

Bearing Pressure

The bearing pressures encountered in practice may be moderate or excessive.

Excessive load on the bearing may be due to a greater weight than was intended, too great a belt pull, abnormally heavy service for the machine, incorrect alignment of the shaft bearing, or faulty mechanical adjustments.

*Credit is extended to Engineering Extension Department of Pennsylvania State College, State College, Pa.

Bearing Temperature

The problem of film formation in bearings, as influenced by the operating temperature, may be separated into four temperature ranges—low, moderate, high, and excessive temperatures. Lubricants are influenced by temperature. Therefore, to determine the body which will be correct at service temperature, a heavier—or lighter lubricant must be selected for higher or lower temperatures.

Low bearing temperatures make it necessary to select an oil of correct body that will retain fluidity at the desired temperature. Low temperatures are generally the result of climatic conditions or refrigeration.

Moderate bearing temperatures, most common in general practice, up to about 140° F. (60° C.) (a temperature that can be borne by the hand) do not involve the special problems of the lower or higher temperature ranges.

High bearing temperatures result from frictional heat in the bearing, from deficient heat radiation, from high surrounding temperatures or from heat travelling along the shaft (induced heat). Bearing temperatures above 140° F. (60° C.) demand prompt attention if they are the result of frictional heat and insufficient radiation, since the reduced lubricant body may cause failure of the lubricant film, increasing friction and, therefore, producing greater frictional heat, which may destroy the bearing. When a high temperature results from induced heat, such as the proximity of steam or other source of heat, there is not necessarily any difficulty in maintaining lubrication if a sufficiently heavy-bodied lubricant is selected.

Excessive bearing temperatures, say above 180° F. (82° C.), generally demand special consideration of the oil or grease characteristics to avoid vaporization and carbonization. The character of the lubricant must be such as to give strength to the lubricating film at the high temperature. When such temperatures result from surrounding heat, lubrication is always possible if the speed is high enough to make the lubricant wedge effective in forming the film. Excessive temperature, high pressure and low speed is a combination of conditions that may require the use of a suitable grease.

Film Forming Conditions

Under the term film-forming conditions we may include such influencing factors as the form of the clearance space in the bearing, with such chamfers and grooves as may exist; and the method of supplying lubricant to the bearing. It is the combination of these factors that determines whether film formation will take place, with the assistance of an effective and well supplied lubricant wedge; or whether the film must be formed in spite of an ineffective lubricant wedge and a lubricant supply that is irregular, and therefore sometimes deficient.

Favorable film-forming conditions generally justify or permit the repeated use of the oil; which circumstances calls for the maximum degrees of stability, purity, and durability that are characteristic of oils of special high quality manufactured for this service.

Unfavorable film-forming conditions are generally found in company with oiling methods which do not require repeated use of the oil. While the durability of the oil is not so essential in this case, the qualities which increase adhesiveness and film strength must be sufficient to relieve the effects of the adverse mechanical conditions; and hence the need is still for an oil of high quality, manufactured with these properties in view.

Where film-forming conditions are bad and frictional losses are disregarded, the strong adhesiveness of oils of extra-heavy body may be utilized.

Presence of Impurities

Water in a bearing constitutes an impurity that may seriously interfere with the maintenance of the lubricant film unless the proper precautions are observed. With an all-loss method of supply, such as hand oiling or drop-feed oiling, the use of a correctly compounded oil results in an emulsion that adheres to shaft and bearing surfaces and provides an effective lubricating film. Where the method involves the repeated use of the oil, the presence of water in the bearing lubrication system requires the use of a pure mineral oil possessing a high degree of durability, and those characteristics which favor ready separation of water and other impurities.

Solid impurities, especially when of hard and abrasive nature, cause serious wear and should be kept out of bearings. Covers should be provided for oil holes and for lubricating devices. Where abrasive dust is present in quantity, it is sometimes advantageous to apply grease by means of compression cups or grease systems.

Bearing Troubles

Correct lubrication may be regarded today as a science. Just as the chemist knows what results will follow the mixing of two substances under known conditions, so the fully-informed lubrication engineer can foretell what will be the effect of applying a given lubricant to a bearing subjected to known mechanical and operating conditions.

Incorrect analysis of the factors influencing lubrication, failure to observe the true conditions, and lack of knowledge of the correct lubricants, necessarily lead to incorrect lubrication; **and the penalties are:** troubles, wear and repairs, depreciation of equipment, and the expense of replacement. This negative aspect of lubrication will be discussed now, in order that incorrect conditions may be rectified.

Indication of Bearing Troubles

Bearing troubles may make themselves known in a number of ways, each trouble resulting from one or more of several causes.

Hot bearings, eccentrics and guides, generally indicate excessive frictional losses. The temperature rise may be excessive, leading to further troubles; such as **seizure of the bearing surfaces, the melting of the bearing metal and damage to the journal.**

A knock in the bearing may be the result of too great clearance, due to wear or improper adjustment or due to the need of a heavier oil than that in use.

Rapid wear of bearings and journals may call for frequent repairs and renewals, or may cause the parts of the machine to run out of proper alignment.

Unnecessary friction may be observed through an increase in the power that is demanded to operate the machinery.

Causes of Bearing Troubles

A complete lubricant film has been shown to be the great essential of correct lubrication. Hence, incorrect lubrication which leads to troubles is due to conditions that interfere with the formation and maintenance of an effective lubricant film.

The causes of bearing troubles may be classified under the following six heads:

1. **Incorrect structure of the bearing;** as influenced by materials, design, workmanship, adjustment and wear.
2. **Excessive pressures** resulting from misalignment, heavy belt pull, or overload of the machine beyond its designed capacity.
3. **Temperature extremes** resulting from surrounding conditions, hot or cold, or from frictional heat and deficient radiation.
4. **Contamination of the lubricant** before or during use in the bearing.
5. **Incorrect methods and practices** of lubrication.
6. **Unsuitable lubricant** for the conditions.

Faulty Design

The introduction and distribution of a lubricant within the bearing, the formation of the film and the effectiveness of the film in reducing friction are all dependent upon the materials and physical form of the bearing as resulting from design, workmanship, adjustment and wear.

Unsuitable materials—too hard or too soft, to granular or too fibrous—are sometimes, though rarely, the cause of bearing troubles. The subject of material selection is well understood by machine builders today.

Insufficient bearing area, resulting from faulty design, is rare in modern machines. It results in an excessive unit pressure on the bearing surface and enhances the importance of the correct formation of the surfaces to produce an effective lubricated wedge. It may also require the use of a heavier-bodied oil in spite of the greater fluid-frictional losses which result.

Ineffective or insufficient oil or grease inlets prevent complete lubrication. In a long bearing, two or more inlets are usually necessary. If the inlet enters the bearing clearance on the pressure side, it will be closed by the journal; so that lubricant cannot enter except by applying it under high pressure. This trouble often occurs where the inlet holes are on the top of the bearing and there is a strong upward belt pull on the shaft. The location of the inlets should be changed to a low-pressure area.

Uneven bearing surfaces, due to poor workmanship, result in a reduction of the true bearing area; making it impossible to maintain a strong supporting lubricant film. Wear may correct this fault or make it worse. The exact formation of the bearing surfaces by good workmanship is important.

Insufficient clearance, either from making the bearing and shaft too close a fit or from too tight an adjustment, prevents lubricant distribution and film formation.

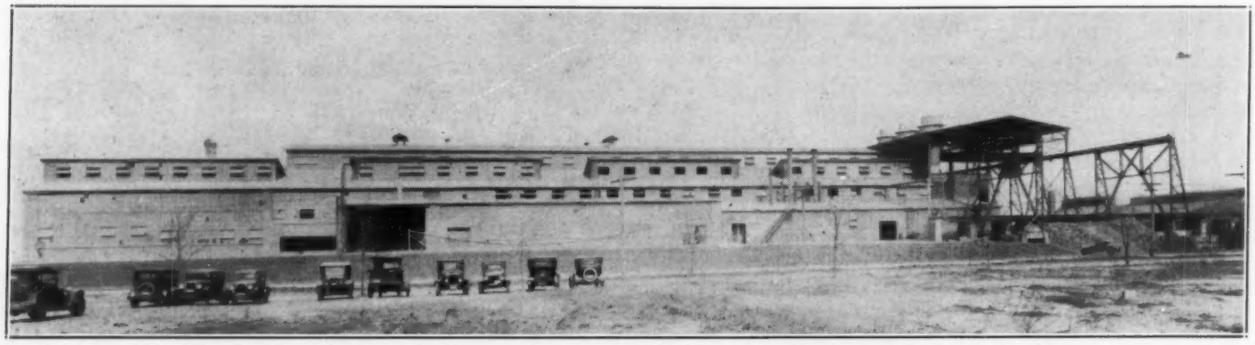
Excessive clearance, resulting from inaccurate workmanship, wear, or loose adjustment, reduces the

effective pressure of the lubrication film, and promotes lubrication waste.

The lack of a wedge-shaped clearance, in which the film pressure can be built up in order to support the load, is the cause of many bearing troubles. This occurs in bearings with small clearance, and is relieved by beveling the sharp edges of the bearing parts and "easing away" the surfaces of the bearing adjacent to the bevel. This may be done by scraping or machining. Where grooves are employed, the edges should be rounded or eased away.

Incorrect grooving may permit the lubricant to escape from the end of the bearing or may destroy the film pressure at the point where pressure is required. Unnecessary grooves are harmful.

Wear of chamfers and grooves may in time destroy their effectiveness or creat sharp edges that cut away the film.



The Application of the Electric Motor to the Production of Cast Iron Pipe †

By GEO. PFEFFER*

The object of this paper is to show the application of the electric motor to the production of Cast Iron Pipe. A brief history of the cast iron industry seems to me would not be amiss at this time—therefore, with your permission, I will briefly outline its history.

Iron was first produced as long as 6,000 years ago, but was first cast in the form of pipe about the year 1664. This was in France, and was of the flange type, and supplied water to Versailles. It is still in use, a record of 264 years service. The length of the line is 15½ miles—75% of it is 12¾" inside diameter with a wall thickness of ⅞", while the balance is 20" inside diameter with a wall thickness of 1⅜". The length of each section was about 40". So far, the only repair necessary has been the renewal of the bolts and nuts which are used for clamping the sections together.

From here we can trace the development of our modern pipe system. The most extensive use for Cast Iron pipe is for conveying water, gas and steam, and for pressures as high as 300 pounds per square inch.

Its popularity is due to its low cost, and ease of laying, but most important the splendid service which it gives, especially underground where other materials, due to their poor resistance to corrosion and mechanical strength, fail to give good service.

In 1799 a Water Works was formed in New York City, called the Manhattan Company . They used water pipe made from bored pine logs. Philadelphia was also laying a log pipe system at the same time, and after a number of breaks, they ordered some cast iron pipe from England. Their experience with these was so satisfactory that New York and Baltimore quickly followed suit and also imported cast iron pipe from England for their gas and water lines.

This was the beginning of the cast iron pipe industry in the United States.

Today it is the cheapest cast iron product on the market, which is accounted for by the fact that only the most modern machinery and methods are used, competition being so keen that it will not permit antiquated methods being used.

To illustrate this point more clearly, the author will briefly describe the various methods used in the manufacture of cast iron pipe from the first foundry in Millville, N. J., in 1803, to the present time.

Originally, cast iron pipe was horizontally cast in sections 4 to 5 feet in length. The mold or cavity into which the molten iron was poured was formed in 2 boxes of damp sand each containing an impression of half the outer circumference of the pipe, and by closing these two half molds around the core, whose diameter is the inside diameter of the pipe to be cast. This method of horizontally pouring was used about 150 years ago, when the pouring on the bank system was adopted, that is, the mold and core were slightly raised on one end which permitted pipe of nine foot length to be cast, due to the fact that

†Presented before Philadelphia Section, A. I. & S. E. E.

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the core did not tend to deflect so readily while in this position.

Lately another method of making cast iron pipe has been adopted and is known as Centrifugal or "SandSpun" process.

While the casting of metals centrifugally has been known for many years, the successful casting of cast iron pipe by this method has only been accomplished in recent years.

In 1925 there was erected at Florence, N. J., a foundry for the centrifugal casting of pipe, which is known as the Sand Spun Foundry. This building is approximately 400 feet long and 135 feet wide, having a capacity of over 400 tons of Sand Spun pipe per 24 hours, ranging in size from 4 to 16 inches inside diameter, and all of them 16 feet long. It has a connected load of 2000 horse power, which is made up of motors ranging in size from 1 to 100 horse power.

Some idea of the size of this building can be had from figure one.

The molds in which the pipe are to be cast are formed in a small tube or cylinder of cast iron called a flask. These flasks are very carefully machined both inside and out, and heavily ribbed for strength. These flasks are placed either singly or in pairs, depending upon their size, on the table of a machine called a tilting table. This device takes the flask and raises it from the horizontal position to a vertical position and locates it on a Ramming Machine,

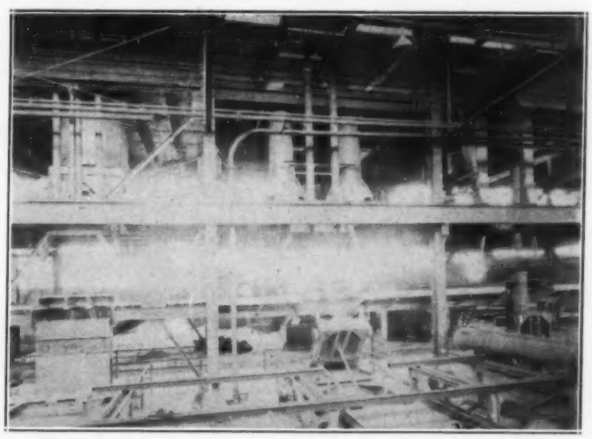


FIG. 2.

where it is rammed by an up to date method. (Figure two). Two long cylinders termed the patterns are then lowered into the flask by means of the 55 horse power motor arranged similar to Crane A Trolley except that it is held in an accurately fixed position directly over the mold. These patterns are of the same diameter as the outside diameter of the pipe to be cast.

The bottom end of the patterns are held in the center of the flask by means of the head patterns, and by means of a centering device at the top.

Sand which is of the ordinary foundry type, that is, open grained, heavily bonded, is then fed into the top of the flasks, filling the space between the flask and the pattern from a reservoir located directly over top of the mold. These reservoirs or storage tanks hold approximately 20 tons each. After the space has been filled, ramming is then begun, until the sand is thoroughly packed. The pattern or patterns are then withdrawn, leaving a hard solid mold. A facing termed blacking, which is in a liquid state, is then poured down the inside of the mold and sand in such a manner that it completely coats the inside of the mold with a very thin layer. The facing is used to prevent fusion of the molten iron when it comes in contact with the sand of the

FIG. 3.

mold. The flask containing the sand, and which is now termed the mold, is then lifted off the ramming machine by the tilting table which causes the mold to be lowered from the vertical position to the horizontal position onto a pair of skids. While in this position a flame is passed through the mold for a short time in order to dry the wet blacking on the interior surface of the mold. See figure three.

From here it is conveyed by means of a traveling crane to a spinning machine. Before being placed in the spinning machine, an oil sand core is carefully fitted into the bell end of the mold and is of the same size and shape as the inside of the bell of the pipe to be cast. See figure four.

FIG. 4.

The Spinning Machine consists of a very heavy cast iron base, cross section of flask and rollers, upon which are mounted four large rollers, in such a way that the flask, when in the machine, rests upon these rollers. On one end of the Spinning Machine is a

specially designed 25 horse power motor, having a speed range of 400 to 1600 RPM, with a specially designed Magnetic Clutch mounted on the pulley end. The opposite end of the Spinning Machine is arranged so that it can be raised about 15 degrees from the horizontal, the motor end being hinged at the base. See figure five.

FIG. 5.

The flask or mold is now rolled onto the rollers—the bell or large end is pushed tightly against the face of the Magnetic clutch—a cover large enough to cover the mold and clutch is then lowered by means of a hydraulic ram over the mold—power is applied to the Magnetic clutch firmly coupling the motor and mold together. The "start slow" button is then pressed—this permits a low voltage to be applied to the armature of the motor through a specially designed controller, causing the motor and mold to revolve at a slow speed of approximately 50 R.P.M.

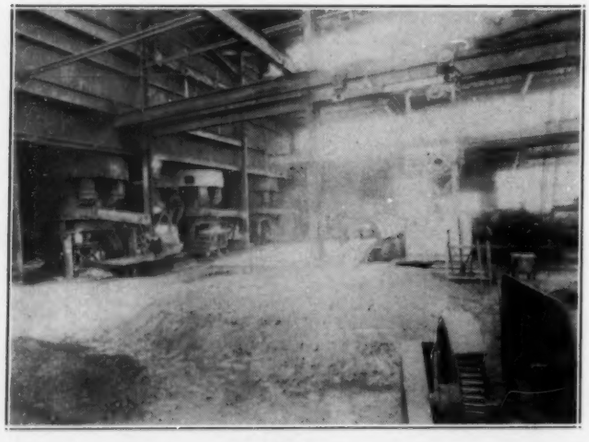


FIG. 6.

At this time a large ladle containing molten iron, which is melted in a 62" cupola, blast being furnished from an 85 H. P. 3 phase, 2300 volt centrifugal blower (three cupolas are shown in figure six and each blower is run for 24 consecutive hours which arrangement permits each cupola to be used every third day) is brought to the other end of the spinning machine by means of a Monorail Crane (figure seven), from which molten iron is poured into a small ladle which is fastened to the Spinning Machine and which holds the required amount of iron to make the pipe. Hydraulic pressure is then fed into a cylinder placed under the spinning machine, which causes the end of the spinning machine, opposite to where the motor is placed, to raise several degrees from horizontal. The hydraulic

FIG. 7.

pressure is then allowed to exhaust from the cylinder slowly causing the spinning machine to return to the horizontal position. While this is taking place the small ladle containing molten iron is tipped, causing the iron to flow from the ladle into the mold by means of the specially constructed spout; by the time the table has almost returned to the horizontal position, the iron has been poured from the ladle into the mold, and just at this critical moment the motor is automatically removed from the low voltage position to the line voltage position, through the controller, causing the motor to be rapidly accelerated from the low speed of 50 R.P.M. to a predetermined speed anywhere from a 400 to 1600 R.P.M., depending upon the size of pipe being made. This high speed causes the metal to be thrown to the sides of the molds, due to centrifugal force.

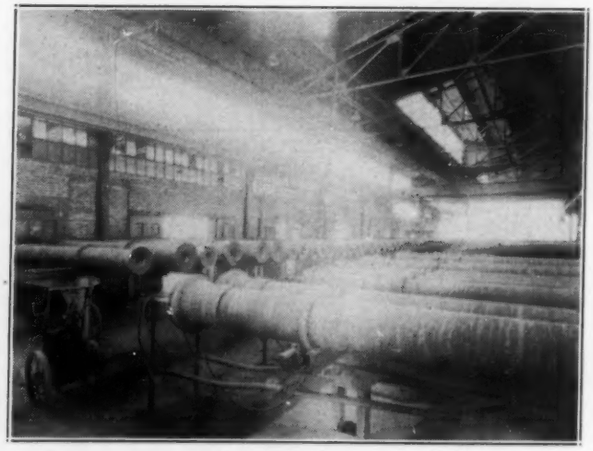


FIG. 8.

In order that the metal may be evenly distributed both in the length of the mold and the thickness of the wall, all of the movements such as the pouring of the metal, the lowering of the spinning machine, and acceleration of the motor, must be carefully synchronized.

Just while we are on the acceleration of the motor, this was brought to our attention:

At the time of computing the size of the motor necessary for this equipment, the formula known to all of you for accelerating large masses such as fly

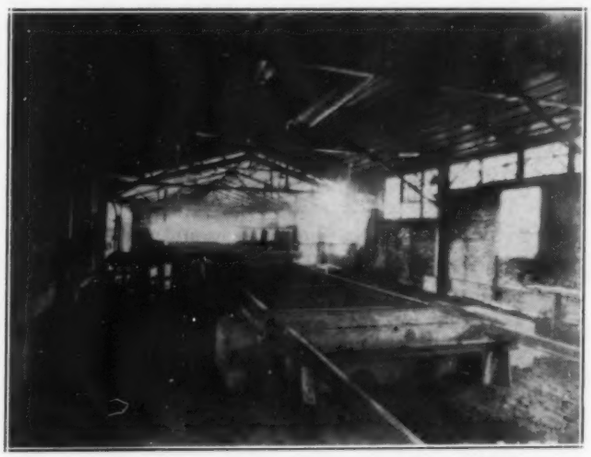


FIG. 9.

wheels, etc., was used. To our surprise a great deal more current was taken by the motor while accelerating than what the figures showed. It was found that the actual power required was from 75 to 125% more than the computed power. For a long while we endeavored to account for this error. Even after careful check by various engineers of the figures, no error was found. However, a number of experiments were made to determine where these errors might be. It was found to be due to the friction between the

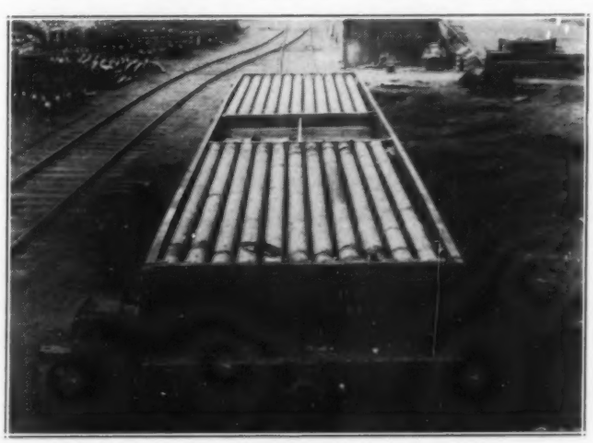


FIG. 10.

molten iron and the sides of the mold. This can best be shown by knowing that while the mold is being rotated in the clockwise direction, that the iron was actually flowing in the counter clockwise direction. This caused considerable friction until the mold was accelerated sufficiently to cause the iron to be distributed over the walls of the mold . The current required by the motor to keep the mold revolving after it was accelerated was only about 15% of the full load of the motor.

The flask containing the molten iron is then revolved at this high speed until the metal contained in it solidifies, which is anywhere from three minutes for the smaller size of pipe up to as high as twenty minutes for the larger sizes.

When the metal is sufficiently solidified the motor is stopped, the cover raised, and the mold is then automatically ejected from the Spinning Machine onto a pair of skids. The head core is then removed, after which the mold is transferred by means of a crane onto another pair of skids (figure eight) where it remains until cool. It is then put on a machine called a stripper. This stripper consists of gear reduction driven by a 20 Horse Power Motor. Mounted on the other end of this gear reduction is a pair of jaws hydraulically operated, which grips the outside of the flask and revolves it by means of the 20 horse power motor. On the other end of this stripper is a large arm containing three jaws, which fit inside of the pipe. These jaws are so arranged that they cannot revolve, and after they are placed inside of the pipe they are expanded, gripping the pipe very firmly.

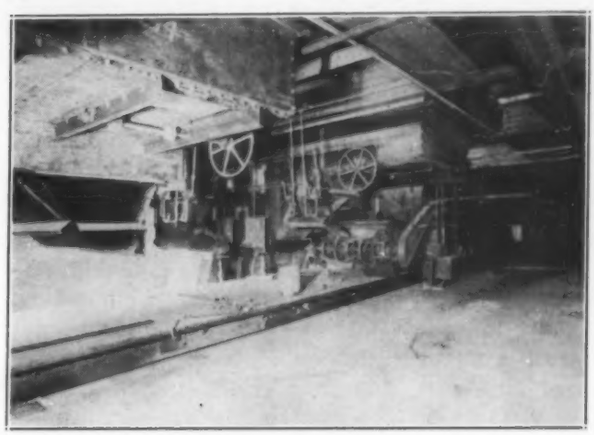


FIG. 11.

Power is then applied to the 20 horse power motor, causing the mold to revolve very slowly. This breaks the seal caused by the sand between the pipe and the flask. After a very short time the pipe is entirely free from the mold. Then the long arm containing the three jaws is slowly withdrawn from the inside of the flask. The sand which slowly oozes from the flask is caught in a large tank arranged under the stripper. This sand is full of lumps and very dry, and quite unsuitable in this state to be used for the mold again until it has been reconditioned. A device used for reconditioning the sand will be described later. We will now follow the pipe from the stripper to what is termed the Cleaning shed. Here the pipe is carefully cleaned of any small adhesions of sand that might have adhered to it, after which it is put on to another pair of skids where the interior is cleaned by means of a motor driven cleaning wheel, which cleans the interior of the pipe of the dross and dirt which is forced from the iron to the inside of the pipe by centrifugal force. It is then carefully inspected by experts known as pipe inspectors. Their duties are to see any imperfections that this pipe might contain, and also to measure the pipe for the proper wall thickness and the outside diameter of the pipe at the bell end, for if these points are not of the proper size, the pipe will not go together. From

here they go into an oven where they are heated to about 350 degrees Fahrenheit, after which they are withdrawn and placed while hot in a tank of tar, which gives them a coating required by the specifications. They are then weighed, again inspected, and the weights marked into the interior of the pipe.

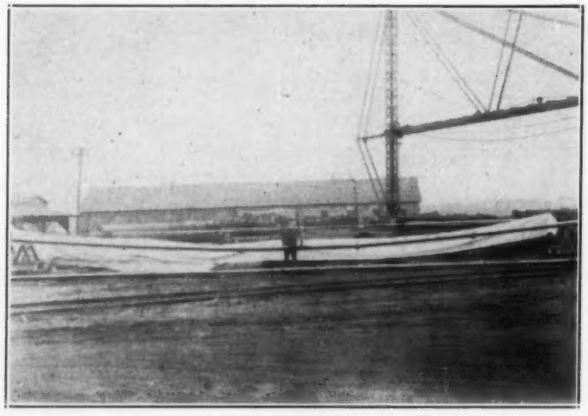


FIG. 12

They are then placed into a machine where both ends are closed. Figure nine. The pipe is then filled with water and the pressure raised until it reaches 500 pounds. If the pipe tests O.K. it then is placed in the cars (figure ten) and shipped or placed into piles and held ready for shipment.

Now to return to the sand which has been removed, as previously stated, from the flask and stored into storage bins under the strippers. These storage tanks have a capacity of about 20 tons of sand. Directly under these storage tanks is a long motor driven car which has a capacity of about 15 tons of sand. The required amount of sand is placed on the car from the storage tanks, where it is carefully treated with various ingredients, water of the required amount, etc. It is then thoroughly mixed by means of two large drums or cutting cylinders (figure eleven), both motor driven, until the sand is of a proper mix or temper, which is determined by means of Standard A. F. A. tests made by a sand expert. When it has been pronounced O.K. by the sand expert, it is fed from the table onto a long conveyor belt by means of a motor driven Helix or worm. The conveyor then takes the sand up to the large tanks which are placed over top of the Ramming Machines.

A pipe made by this process is superior to cast iron pipe made by other processes. It is absolutely homegeneous, free from blow holes and has a wall thickness of metal that is even and of greater strength. Sand Spun pipe being of 25% greater length than the old method of pit cast, reduced the cost of laying, also due to its ductility it can better stand the shocks from heavy traffic such as we have to contend with on our streets and roads today. Some idea of this matter of ductility is shown in figure twelve, also strength and wall thickness. Another item which may be of interest to many of you is that called the cement lined pipe. By this I mean pipe that has a thin coat of cement applied

FIG. 13.

centrifugally on the interior surface. The claims for these pipe are that it reduced friction loss about 12%. It discourages growth on the interior of the lines which is very common in pipe lines, which are not treated thus, and while this coating is very thinly applied, it is very smooth and adhesion is so great that even though a pipe is cut off by the method of Hardy and Maul, the lining does not chip or flake off.

A comparison is shown between a 4" pit cast pipe 12 ft. long and a 48" Sand Spun Pipe 16 ft. long, figure thirteen.

IRON AND STEEL EXPOSITION

Public Auditorium **Cleveland, Ohio**

June 15, 16, 17, 18, 19, 1931

The Fifty Million Dollar Market For Steel Mill Equipment. Floor Plans, Etc., Supplied on Application.

The Application of the Electric Motor to the Production of Cast Iron Pipe

By GEO. PFEFFER

DISCUSSION

Discussed by

J. E. Brown, Dravo & Doyle Company, Schaff Building, Philadelphia, Pa.

H. D. Esterly, Assistant Superintendent, Electrical Department, Alan Wood Steel Co., Conshohocken, Pa.

C. M. Thompson, Engineer, Henry Disston Sons Company, Philadelphia, Pa.

Louis G. Camerota, Plant Engineer, Florence Pipe Foundry & Machine Company, Florence, N. J.

R. M. Fuller, Consulting Engineer, Riverton, N. J.

John McTamney, Electrical Department, Midvale Steel Company, Nicetown, Philadelphia, Pa.

F. O. Schnure, Superintendent Electrical Department, Bethlehem Steel Company, Sparrows Point, Md.

J. E. Brown: It is rather noteworthy to see how the Ordnance Department of the United States Army adapts some of these new process applications in industrial plants to their own uses. Of course we are all interested in peace and talking peace, but it is well to know that some people are thinking of eventualities in case of future war. The Ordnance Department has applied the principle to manufacturing spun sand centrifugally-cast steel in the form of one-piece gun tubes. Those tubes are placed in very heavy molds and subjected to a tremendous internal hydraulic pressure. So Mr. Pfeffer can see that if another war breaks out he might be called upon to help make guns instead of pipe.

H. D. Esterly: There is one thing I am interested in knowing—How much of this cement do they put into this pipe?

Geo. Pfeffer: About 1/32" wall.

H. D. Esterly: Is that just straight cement or sand?

Geo. Pfeffer: Specially prepared cement.

C. M. Thompson: My question is whether the cement was spun in the pipe?

Geo. Pfeffer: Very much in the same manner in which the iron is poured; the cement is placed in the pipe in a manner similar to the spinning process.

C. M. Thompson: That spinning process is longer than the casting of pipe?

Geo. Pfeffer: No much shorter in applying, but it takes longer to season.

Louis G. Camerota: As Mr. Pfeffer has explained, it is absolutely necessary those flasks be almost perfect. Of course you appreciate, when revolving at a high rate of speed, if you have the slightest unbalanced condition you get vibration and get a very poor specimen of a pipe.

You probably referred to my inspection of your flasks. Nevertheless, it is just as easy to have a perfect flask as it is to have a poor one. Those flasks are called upon to render a certain service, and unless they are very nearly perfect they render poor service. I appreciate this is a very much abused word, but, nevertheless, one we must deal with.

I might say again, in connection with service, that electricity has been successful because it has been the kind of service which no other force known today has rendered, and I want to add that sand spun pipe will render a service that to date has been unknown in the cast iron pipe field.

R. M. Fuller: I want, in the first place, to congratulate Mr. Pfeffer on his very interesting paper and his able presentation of it.

1. I should like to ask him whether or not, in spinning this pipe when the hot metal is first poured into the mold, is it being rotated?

2. Is there any particular space between the inner wall of the pipe and the core?

3. I also wondered whether or not the same standard spinning bed was used for all sizes of pipe.

Geo. Pfeffer: 1. The mould is rotated while the metal is being poured.

2. No core is used in this method of casting pipe except on the bell end its use is to form the interior of the bell or socket end.

3. As to the last question, the same machine is used for all sizes up to 16"; from there on we use another size. We could make all sizes on one machine but it would not be good practice.

John McTamney: I feel Mr. Pfeffer is to be congratulated for his wonderful paper.

He spoke of a specially designed motor for the twister. In what way is that specially designed?

Geo. Pfeffer: That was specially designed for this process. We do not care to discuss its special design.

F. O. Schnure: After congratulating Mr. Pfeffer on his paper, which we have heard so much about for the last four years, I want to ask whether a magnetic clutch is necessary?

Geo. Pfeffer: A magnetic clutch is used more for simplicity and speed of coupling the motor to the flask.

F. O. Schnure: It makes a very satisfactory coupling?

Geo. Pfeffer: Very satisfactory.

Items of Interest

A. I. & S. E. E. INSPECTION TRIP TO THE STEUBENVILLE PLANT OF THE WHEELING STEEL CORPORATION

About 400 prominent engineers and executives of the Iron and Steel Industry, from all over the United States attended the Inspection Trip of the Steubenville Plant of the Wheeling Steel Corporation on December 3, 1930. After the Inspection Trip the group were guests of the Wheeling Steel Corporation at a luncheon at the Fort Steuben Hotel.

At the technical session a paper was presented by Harry A. Winne of the Engineering Department of the General Electric Company of Schenectady, N. Y.

Mr. Henry A. Roemer, just elected President of the Sharon Steel Hoop Company and Mr. J. B. Andrews, President of the Andrews Steel Company were honor guests on the Inspection Trip.

H. D. Esterly has been appointed Electrical Superintendent of the Alan Wood Steel Company. He succeeds the late H. A. Lewis who died October 3, 1930.

Mr. Esterly is a very active member of the Association of Iron and Steel Electrical Engineers, and

H. D. ESTERLY,

was recently elected Vice Chairman of the Philadelphia Section. Mr. Esterly is also a member of the National Membership Committee. The Association of Iron and Steel Electrical Engineers extend their best wishes for his success in his new connection.

PERSONNEL CHANGES

Lorenz Iversen, vice president, Mesta Machine Company, Pittsburgh and West Homestead, Pa., has been elected president to succeed the late Harry F. Wahr. Mr. Iversen has been associated with the company for many years. Prior to his election as vice president in 1925 he had been chief engineer.

L. W. Mesta has been elected vice president. He formerly was assistant general superintendent and has been with the company since his graduation in mechanical engineering in 1911 from the University of Pittsburgh.

F. A. Mesta has been elected director to fill the vacancy on the board caused by the death of Mr. Wahr.

Paul Llewellyn, formerly president, Interstate Iron and Steel Company, Chicago, has been elected chairman of the board of the reorganized Empire Steel Corporation, Mansfield, Ohio. He had been president of Interstate since 1925, having previously been vice president in charge of sales. George M. Smith is general superintendent, Stanley A. Richardson, chief metallurgist; Frank B. Handy, assistant secretary; Burton L. Verner, purchasing agent, and Albert Meihack, open hearth superintendent. All formerly were with Interstate Iron and Steel Company, at Chicago, and all now are located at the Empire general offices, Mansfield.

W. W. Holloway, formerly president of the Wheeling Corrugating Company, largest subsidiary of the Wheeling Steel Corporation, Wheeling, W. Va., was elected president of Wheeling Steel Corporation on October 29 in succession to Isaac M. Scott, who has retired to rest and travel. Mr. Scott had served in that office continuously since 1920, when Whitaker-Glessner Company, La Belle Iron Works, and Wheeling Steel and Iron Company were merged under the name of Wheeling Steel Corporation.

Severn P. Ker, president, Sharon Steel Hoop Company, Sharon, Pa., since 1910, has resigned to become chairman of the board of directors. Company by-laws are being altered to permit of Mr. Ker's election to that office and the selection of a president to succeed him.

Henry A. Roemer, president, Continental Steel Corporation, Kokomo, Ind., since its inception in 1927, has resigned to become president of the Sharon Steel Hoop Company, Sharon, Pa., and Youngstown, O. Effective January 1, he succeeds Severn P. Ker, who resigns after 21 years in that office.

Taylor Allderdice, formerly president of the National Tube Company, Pittsburgh, has been elected secretary and manager of the Carnegie Hero Fund Commission, Pittsburgh, in succession to the late F. M. Wilmot.

W. D. Cameron, associate member of A. I. & S. E. E., formerly assistant manager, Detroit office, General Electric Company, Schenectady, N. Y., has been appointed manager there to succeed the late J. Hal Livsey. Mr. Cameron has been affiliated with General Electric for 19 years, the last three at Detroit.

James E. Lose recently was appointed general superintendent of the Homestead, Pa., works, Carnegie Steel Company. His years of affiliation with the Carnegie company, commencing in 1910 when he took the position of tracer with the Carrie furnaces, have given him a broad experience in blast furnace and steel-making practice. They ad-

mirably equip him for his increased duties as general superintendent.

L. A. Kleber has been appointed superintendent, Taylor-Wharton Iron and Steel Company, High Bridge, N. J., succeeding H. R. Lange, resigned. Mr. Kleber had been superintendent of the foundry at the Taylor-Wharton Company's Easton, Pa., plant.

Stanley Apgar, who has been superintendent of the High Bridge foundry, will succeed Mr. Kleber, as superintendent of the foundry at Easton.

Ralph M. Bowman has been appointed purchasing agent, Republic Steel Corporation, Youngstown, O., to succeed W. J. Massman, resigned. Mr. Bowman formerly was purchasing agent, Central Alloy Steel Corporation, Massillon, O., and more recently was buyer in charge of raw materials for the Republic corporation. C. A. Ilgenfritz is director of purchases.

Three changes in personnel have recently been made at the Nuttall Works of the Westinghouse Electric and Manufacturing Company, Pittsburgh, Pa. T. I. Phillips, formerly Superintendent of Metal Stamping at the AB Building, has been appointed Works Manager, succeeding H. A. Houston, who resigned. W. H. Himes, who was in the Mechanical Engineering Department at East Pittsburgh, was promoted to the Manager of the Engineering Department. His appointment followed the resignation of L. F. Burnham. The final appointment was that of L. R. Botsai as Gearing Apparatus Manager, succeeding E. E. Boon, who resigned. Mr. Botsai was formerly Industrial Manager of the Central District.

H. Lee Reynolds Company, who are Sales Representatives for Mercury Manufacturing Company of Chicago, announce that they now have with them Mr. E. E. Jones who is quite well known to users of Material Handling Equipment.

WITH THE MANUFACTURERS

The Allis-Chalmers Manufacturing Company of Milwaukee, Wisconsin has just issued a very attractive bulletin No. 1147, which lists the Main Roll Drives. This bulletin is specifically illustrated with many photographs of Allis-Chalmers installations in steel plants. A copy may be had upon request.

The Norma-Hoffman Bearings Corporation, Stamford, Connecticut, have just issued an attractive catalogue entitled "Greaseal—Felt-protected Ball Bearings." The catalogue is well illustrated and a copy may be had upon request.

The Ivanhoe Division of the Miller Company, Meriden, Connecticut has just issued a catalogue No. 900, which covers their Industrial Lighting Section Equipment. This catalogue contains 54 pages of interesting matter. A catalogue may be had upon request.

The Brown Instrument Company of Philadelphia are distributing a novel illustration of the inductance bridge principal as applied to their Flow Meter design. It is said that approximately 50,000 of the novelty have been sent out to power plant and industrial plant officials throughout the country.

The Holophane Company have issued a new bulletin entitled "Industrial Lighting."

Among the lighting problems printed in this bulletin are high bay, storage yards, outdoor substations and emergency operating rooms.

The Holophane Company, 342 Madison Avenue will be glad to furnish a copy of "Industrial Lighting" upon application.

A Freyn-Design blast furnace plant of 500-ton capacity is to be built at Pretoria, South Africa. The contract for this plant, complete with auxiliaries, was placed by the South African Iron and Steel Industrial Corporation with Ashmore, Benson, Pease and Company, Ltd., Stockton-on-Tees, England, who are the British Associates of Freyn Engineering Company. This order was obtained in the face of keen competition from European engineers and manufacturers. Ashmore, Benson, Pease and Company, Ltd., reports that the selection was much influenced by the American designs which were submitted by Freyn Engineering Company.

Recently the Drendell Electric Manufacturing Company of San Francisco, California, manufacturers of Panelboards and Switchboards was purchased by The Trumbull Electric Manufacturing Company of Plainville, Conn., and the amalgamation of the organization became effective November 1st, under the name of The Drendell-Trumbull Electric Manufacturing Company.

A PORTABLE LABORATORY FOR TESTING OIL

It is common practice for the maintenance men of a public-utility company to remove samples of oil from transformer equipment in the field and take these to the laboratory for testing. This is considered advisable in many cases because complete laboratory equipment has been too bulky to carry in an ordinary automobile and because small-sized testing sets have proved inadequate. On the other hand, there are many objections to this system, such as, loss of time, danger of mixing samples, and the possibility of foreign matter being mixed with the oil.

Apparatus just placed on the market eliminates the necessity of the inefficient method described above. It is an oil test set providing all the advantages of a laboratory but of such size that it may be placed in any passenger car and taken into the field. The equipment is manufactured by the American Transformer Company, of Newark, N. J.

Every employe of the General Electric Company, from president to office boy, who is working 50 per cent or more full time, will contribute one per cent of his December wage to the company's new unemployment fund and the General Electric Company will match such contributions dollar for dollar, it was announced here today by President Gerard Swope.

Under the rules of the unemployment plan, as originally announced, payments were not to be made for at least six months after its inauguration, which would not be until next January or February, but because of the unemployment emergency it was decided to start relief next month but limit payments to a maximum of $15 per week to employes needing assistance. It has also been decided to consider for assistance employes who may not have contributed to the plan but who are in need of assistance.

Approximately 35,000 employes have been contributing to the plan and on December 1 they will have paid in $350,000.

"The rules of the plan, which have been adopted at all the apparatus works of the company and state that no payments shall be made for at least six months after its inauguration, have been waived in this emergency," Mr. Swope stated. "At the present time a substantial number of contributing employes have been laid off for lack of work and under the rules could not be assisted at this time.

"Assistance is needed now. It has been the expressed feeling on the part of a good many who are working, including employes who have not contributed under the plan, that they would like to feel that they were doing their part in helping their fellow employes.

"An unemployment emergency exists and collections will be made for the month of December at the rate of 1 per cent of earnings of all those whose earnings are 50 per cent or more normal. Notification will be given in December as to whether such collections will continue for the month of January.

"The General Electric Company also waives the rules of the plan and agrees to contribute an amount equal to the sum thus raised.

HUGE ORE UNLOADERS AT TOLEDO

Electrically-driven unloaders that pick up seventeen tons of ore at a bite, and that bite every fifty seconds, recently erected on the Chesapeake and Ohio Railroad docks, Hocking Valley Division, at Presque Isle, Toledo, are the latest steps in mechanization of the age-old, time-consuming business of transferring cargoes from ship to shore; and are the first-unloaders to be operated by alternating-current.

The vast amount of ore and coal handled by the lake ports has made it necessary and profitable to trans-ship by efficient electrically operated machinery. Docks in Toledo alone last year handled over sixteen million tons of coal and almost two million tons of ore. The extent of this navigation on the lakes may be judged by bearing in mind that other docks are doing a somewhat similar business. Coming from mines in Wisconsin, Minnesota, and upper Michigan, the ore is shipped from the ports of Duluth, Iceland and Two Harbors to points south, where it goes by rail to the steel mills of Pennsylvania, West Virginia and Ohio. The returning coal reaches Toledo and other southern ports from Ohio, Kentucky, and West Virginia—destined to all ports up the lakes.

Although the docks at this particular slip can take three boats, only one at a time can be unloaded with present equipment. Future installations are contemplated, the present installation consists of three stiff-legged hoists, each with a capacity of 1200 tons an hour. With all three unloaders in operation, a boat of beam up to 65 ft can be unloaded at the rate of 3600 tons an hour. A crew of only three is required for each—an operator, an oiler and a weigher.

The main structure of each unloader, spanning four tracks, moves on main tracks 72½ feet apart, each track measuring two feet, center to center. The forward track is 5½ feet from the dock. Travel is about 50 to 75 ft. a minute.

In operation, the dipper picks up the ore from the holds of the boat, and places it in a 50-ton disc hopper which discharges into a traveling scale lorry. This car, in turn, dumps it into any of the four lines of cars beneath the span. Since the ore is too heavy to be dumped on one spot on the waiting car beneath the span, it is distributed by means of a "pusher" car running between each pair of railroad tracks, which, with a lever extending on either side, is able to move the car or train of cars into proper position. This operation eliminates the necessity of moving the span.

The operator rides in a tiny cab directly above the dipper. In the control room immediately above the three wheels of the upper structure are located both A.C. and D.C. control panel boards.

There are eight motors totaling 1060 HP. on each unloader. The main motions, beam hoist, and trolley travel are operated by direct current, with variable voltage control; all other operations are handled by alternating current, with full magnetic controllers.

The transformer stations are three-phase, 60-cycle, for 6600 volts incoming, and 440 volts outgoing.

The electrical equipment was furnished by the Westinghouse Electric and Manufacturing Company.

NEW FLUID METER BULLETIN

"Mechanically Operated Fluid Meters" is the title of a new bulletin now being distributed by the Bailey Meter Company of Cleveland, Ohio.

This bulletin which is designated as No. 37 describes and illustrates various types of mechanically operated meters and auxiliary equipment for their installation. Colored meter chart records showing results obtained by the application of Bailey Meters to various processes are included, together with sections on orifice and flow nozzle location, calibration, pulsating flow, special conditions and special applications.

This 52-page bulletin also includes a long list of users of mechanically operated Fluid Meters showing installation data for various services and fluids.

OBITUARIES

It is with profound sorrow and regret that the Association of Iron & Steel Electrical Engineers announces the death of one of its members, Henry Harnischfeger, president of the Harnischfeger Corporation, Milwaukee, Wis. Mr. Harnischfeger died on Saturday, November 15, 1930.

Arthur W. Thompson, aged 55, former president, United Gas Improvement Company, Philadelphia, Pa., and Philadelphia Company, Pittsburgh, died November 9 in the latter city. He was a director, Eastern Rolling Mills Company, Baltimore, and held directorships on the boards of several public utilities.

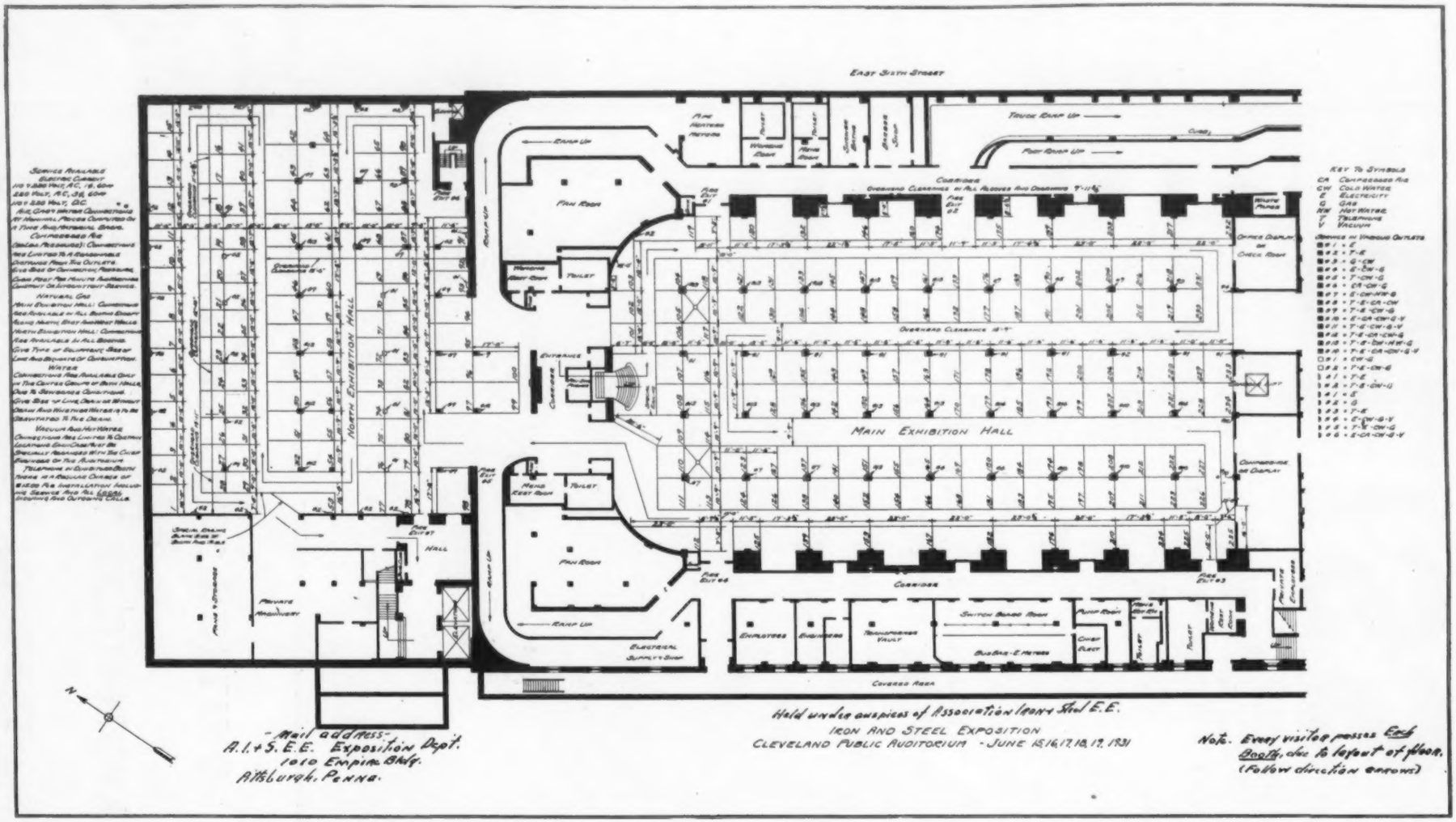
Isaac W. Frank, aged 75, for many years identified with the steel industry in the Pittsburgh district and chairman of the board of the United Engineering and Foundry Company, Pittsburgh, died in this city December 1. He had been ill for six months.

A. B. Neumann, aged 60, member of the engineering staff of Freyn Engineering Company, Chicago, died November 27 at Dusseldorf, Germany. Mr. Neumann was born in Norway but has made his home in Chicago since 1898.

IRON AND STEEL EXPOSITION

CLEVELAND, O., JUNE 15-16-17-18-19, 1931

THE FIFTY MILLION DOLLAR MARKET FOR STEEL MILL EQUIPMENT



Floor plan of the Iron and Steel Exposition held under the auspices of the Electrical, Mechanical, Combustion, Lubrication and Safety Engineering Divisions of the Association of Iron and Steel Electrical Engineers, Cleveland, Ohio, June 15-19, 1931.

You will note that the arrangements of booths are such that every visitor will be required to pass each and every booth in the entire Exposition. To our knowledge this is the first time that any Industrial Exposition has been laid out along these lines.

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ROLLING MILL EQUIPMENT
FOR
HOT OR COLD ROLLING

MILLS

MILL REELS

COILERS

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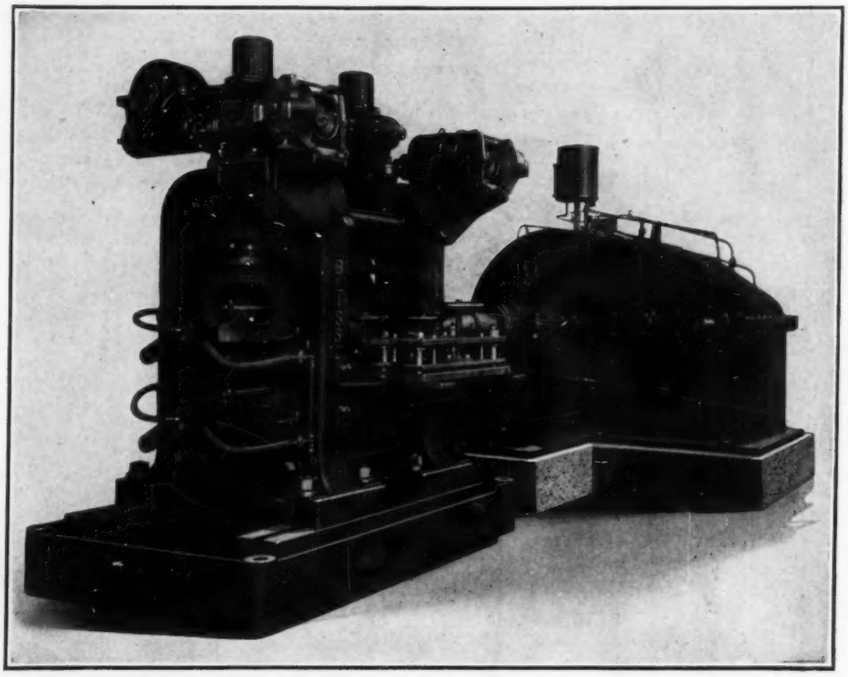
SCRAP-BAILING MACHINES

ETC.

ETC.



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ROLLER-BEARING EQUIPPED

These mills are built in all sizes and roller-bearing equipped throughout.

Full details on request.

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POWER plant practice rushes ahead! No more easy tolerance of ordinary insulation. Apparatus cable must take terrific punishment. Deltabeston Station Cable is made for just that.

Deltabeston withstands overloads, heat, oil, water, abrasion for years and years. It helps central stations meet those ever-threatening emergencies ... adds dependability to any plant.

Heat has no effect on its two walls of long-fiber asbestos, compactly felted on by the special Deltabeston process. Overloads do not puncture its many layers of varnished tape, each good for more than 7000 volts. Abuse leaves its tough asbestos braid jacket unscarred. And the whole cable is water-proofed.

It is armor against fire and breakdown!

Damp-Proof!

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What a wealth of romance clings about the activities of the famous Royal Canadian Northwest Mounted Police! The United States Cavalry had their task cut out for them when subduing the American Indian, and away up North in the land of no shelter the Mounties shouldered the rebellion of the half-breeds on the North Saskatchewan under Louis Riel and Great Bear, in 1869. Out of sight from civilization, over white desolate wastes and facing nature at her cruellest, the Colt, to the Canadian Mounted, often proved his only friend.

On sun-baked prairie and snow-swept slope, Colt has always stood for protection — still available. And today, another form of Colt protection is safeguarding electrical equipment through the NOARK line of safety switches and meter protective devices — for over seven years Colt made. The fine degree of mechanical precision so typical of Colt is clearly seen in the Colt-Noark line. Watch-like methods of accuracy are stamping NOARK products as true members of the Colt family. NOARK products need no introduction to users of electrical equipment, for NOARK is an old and honored name. Its association with Colt assures added progress and protection.

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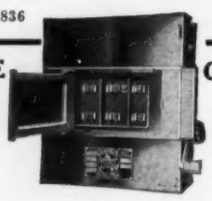
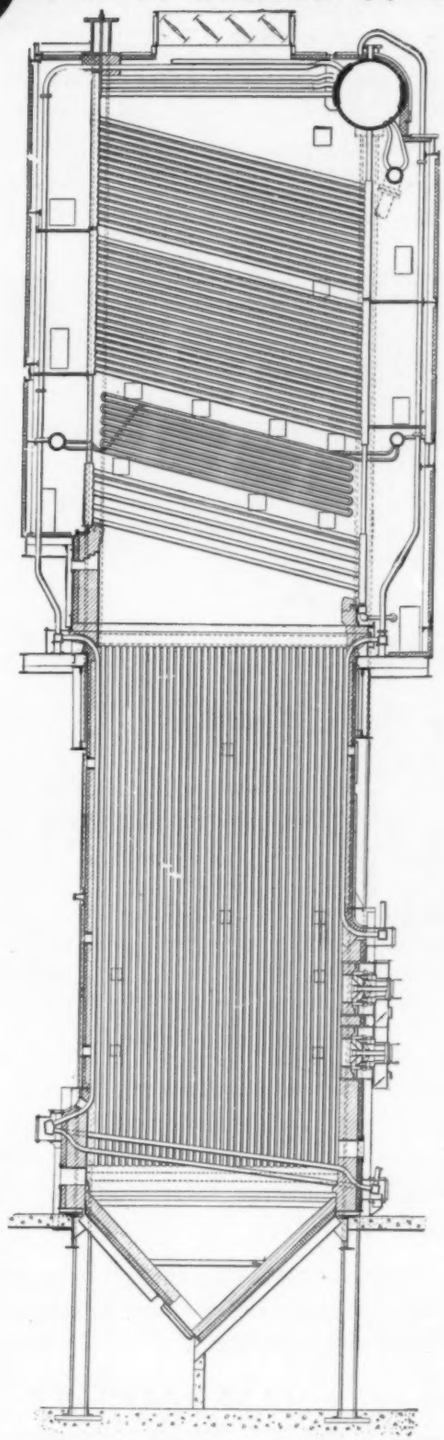
In steel mills, mines, paper mills, chemical plants, and other places where operating conditions are ruinous to ordinary switches, Colt-Noark Quadbreak is standing up.



Send for Catalog "L" and detailed description. "The Rampant Colt," an interesting publication, mailed on request.

One Walsh-Weidner Forged Steel Sectional Header Boiler *to serve a* 25,000 kw. Generator



Sectional elevation of the Combustion Engineering steam generating unit now under construction at the Duluth Steam Electric Station of the Minnesota Power & Light Company.

The Walsh-Weidner sectional header boiler to be installed at the Duluth Steam Electric Station of the Minnesota Power & Light Company is believed to be the largest sectional header boiler ever built.

This Walsh-Weidner forged steel sectional header boiler contains 36,300 sq. ft. of heating surface; is of single pass design, 38 sections wide and 43 tubes high, including 3 rows of circulators. The steam pressure is 485 lb. per sq. in. with a total steam temperature of 760 deg. fahr.

The furnace is of the C-E Water-cooled wall construction and pulverized fuel is introduced through six Lopulco horizontal burners.

This installation is an example of the rapidly growing trend of—one boiler per generator.

Visit Combustion Engineering Corporation's Exhibit at the New York Power Show Booths No. 23, 24 and 25.

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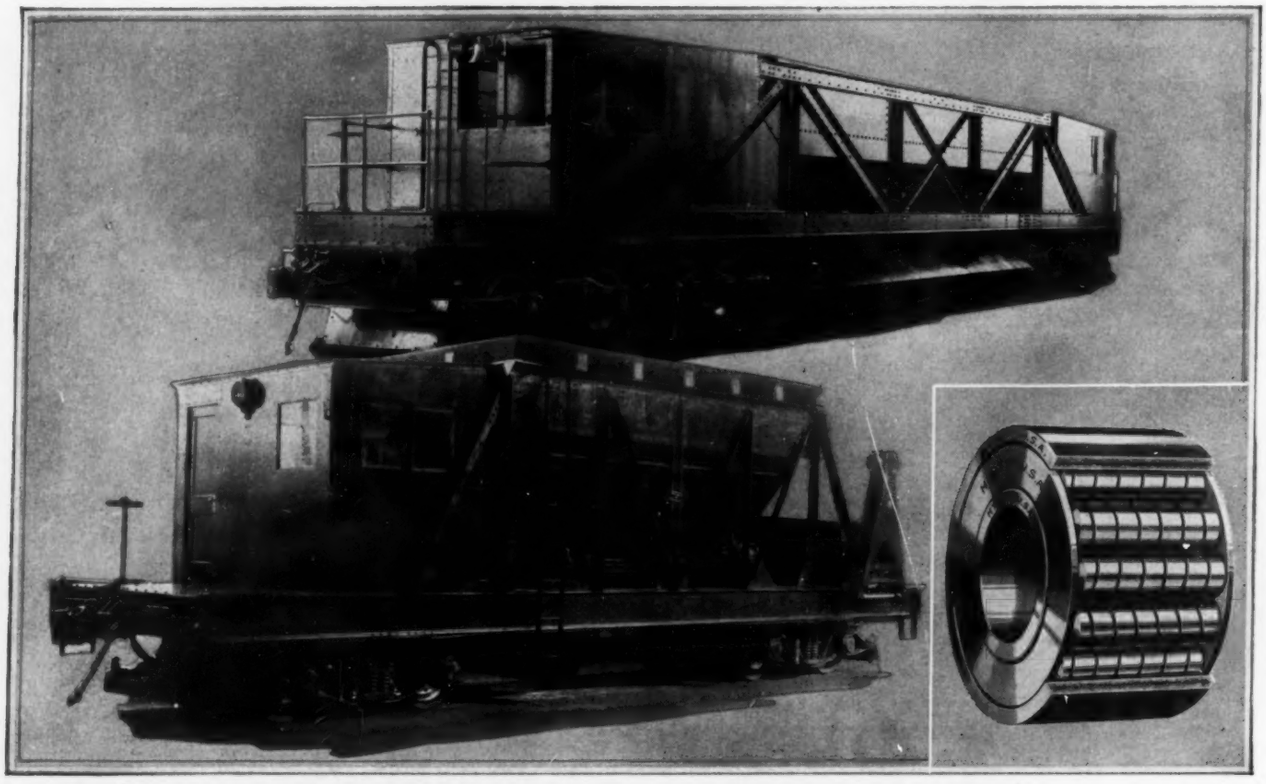
Hyatt Roller Bearings in the journal boxes are designed to withstand just such severe demands as are imposed by ore scale and transfer cars . . . and to withstand them without interruption to production.

Here, where it is essential that cars be kept in constant service, Hyatts bear the brunt of heavy loads and incessant pounding . . . vibration which would impair the performance of ordinary bearings cannot mar the smooth, faultless work of sturdy Hyatts.



Ore scale car and 16 wheel ore transfer car, built by the Atlas Car and Manufacturing Co., Cleveland, Ohio — using Hyatt bearings on all journals.

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SALES AND ENGINEERING SERVICE IN PRINCIPAL CITIES

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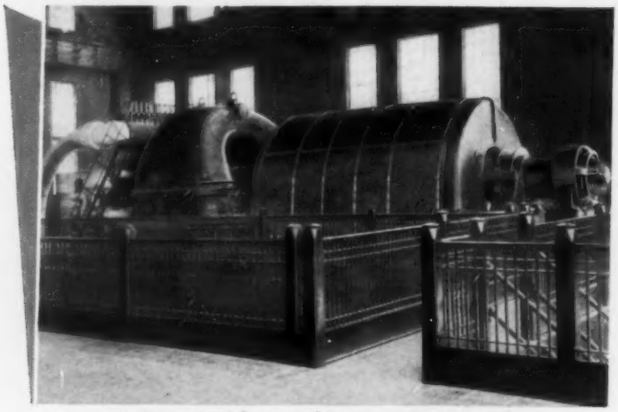
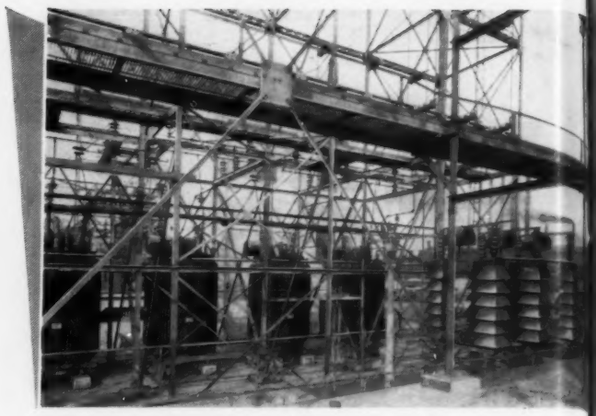


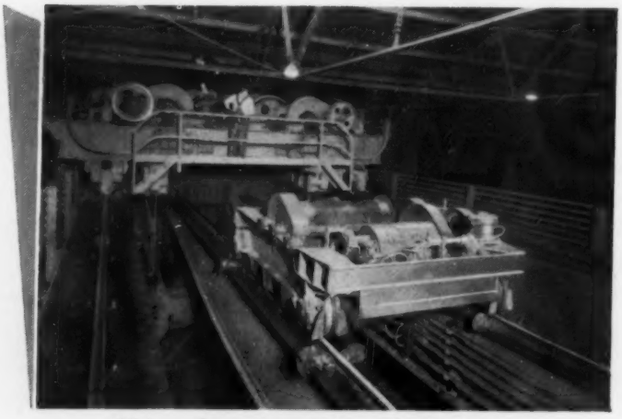
G-E 30,000-kw. turbine-generator set installed in a steel mill. This is the largest turbine-generator set anywhere in use in an industrial plant



G-E outdoor substation equipment serving a mid-western steel mill

G-E instrument and control panels installed in a large mid-western steel plant

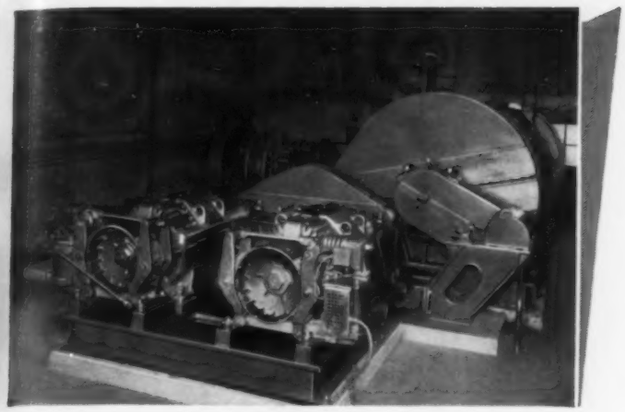
G-E motorized ore bridge in service at a large Pennsylvania iron works



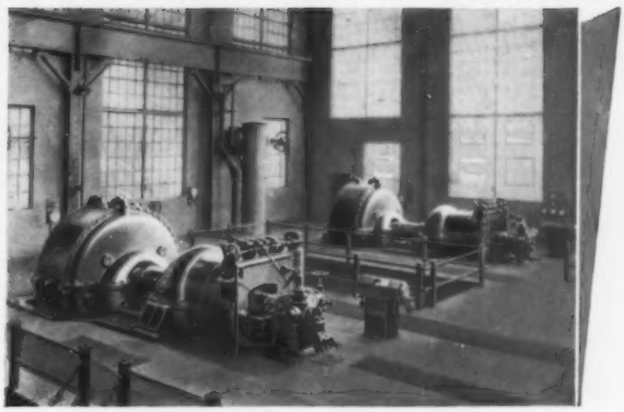
Main and auxiliary trolleys of a G-E motorized hot-metal ladle crane used in an Indiana steel mill

Trolley of G-E motorized charging crane serving a mid-western steel corporation

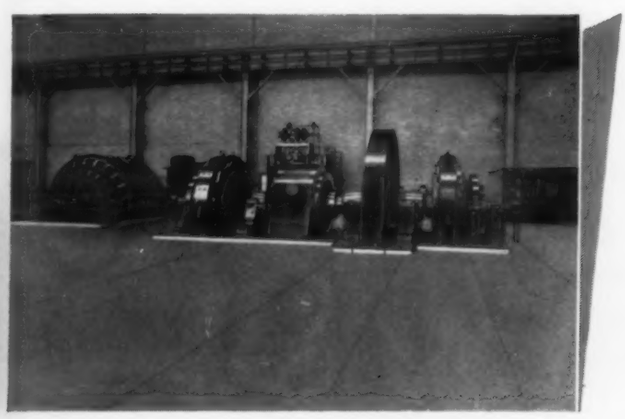
GENERAL



Two G-E Type MDS motors driving blast-furnace skip hoist

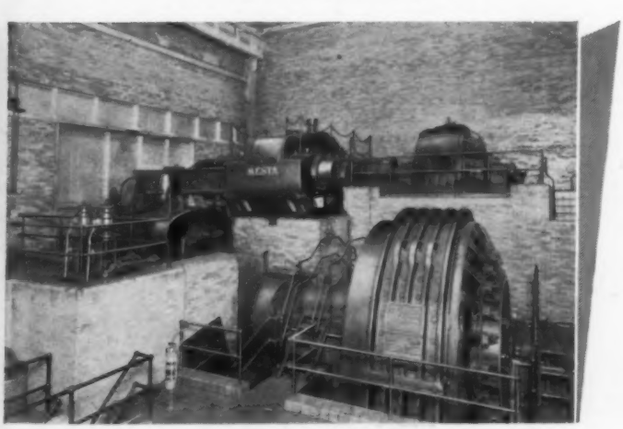


Two G-E blast-furnace blowers in an Ohio steel plant



G-E 5000-hp. reversing motor, G-E flywheel motor-generator set, and G-E control equipment in a large wrought-iron plant

Portion of G-E equipped motor room of a 60-inch-wide hot-strip mill in an Ohio steel plant



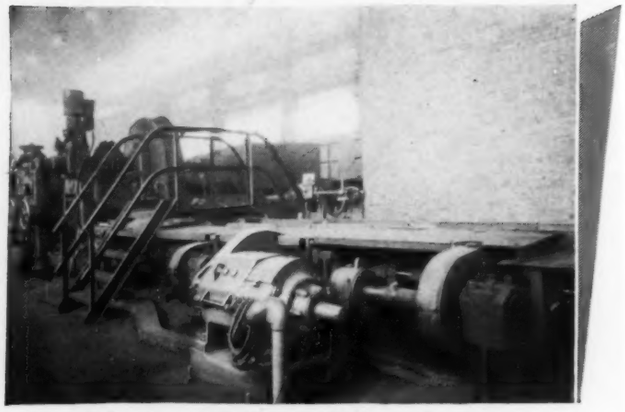
G-E reversing, universal-slabbing-mill drive in the plant of a mid-western steel corporation

Operating pulpit of a G-E equipped 12-inch hot-strip mill

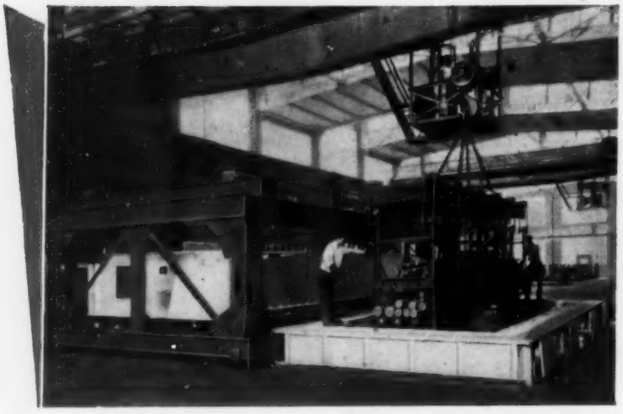
ELECTRIC

Pass in Review!

G-E automatic welding equipment used for crane fabrication



G-E Type MD motor driving approach table to bar mill in a large steel mill



Two G-E 1100-kw. pit-type furnaces for annealing bar stock in a Pennsylvania steel plant

General view, heat treating department of an aircraft-manufacturing plant

FROM ore mines to shipping room, General Electric is prepared to assume unit responsibility in the supplying of electric equipment for every power need. To date, General Electric has built, or is building, motors totaling over one and a quarter million horsepower for main-roll drives, and has supplied the industry with an impressive total of auxiliary drives and control equipments for all purposes.

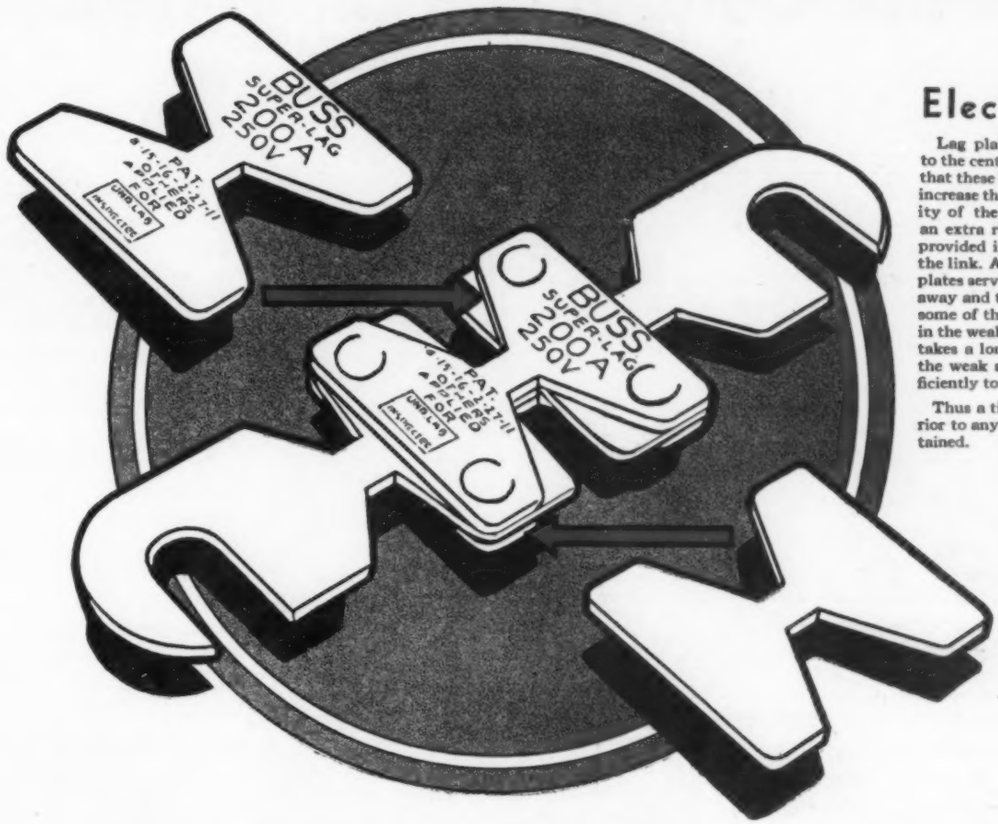
G-E electric equipment is woven into the very pattern of the iron and steel industry. Let your nearest G-E office be of service to you in the solution of your power problems.

200-425

GENERAL ELECTRIC

SALES AND ENGINEERING SERVICE IN PRINCIPAL CITIES

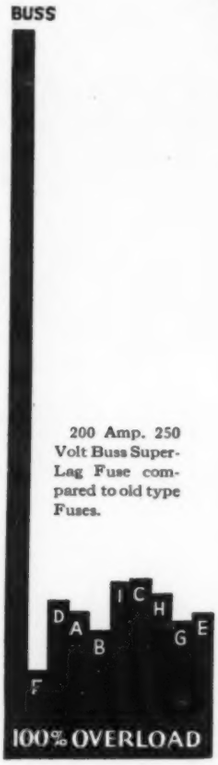
WHY IT WORKS



Electrically

Lag plates are attached to the center of the link. So that these lag plates do not increase the carrying capacity of the link too much, an extra reduced section is provided in the center of the link. As a result the lag plates serve only to conduct away and temporarily store some of the heat generated in the weak spots, so that it takes a longer time to get the weak spots heated sufficiently to blow.

Thus a time-lag far superior to any other fuse is obtained.



200 Amp. 250 Volt Buss Super-Lag Fuse compared to old type Fuses.

To Save the User Money

IN the every day operation of an electrical circuit there are bound to occur many temporary overloads which in themselves would not be harmful to wiring or equipment and would not cause an interruption of service.

When fuses blow needlessly on such harmless overloads, because of a short time-lag, they cause unnecessary and costly shut-downs.

By increasing the time-lag—the time required to blow the fuse—BUSS SUPER-LAG Fuses safely carry many of these temporary or harmless overloads without blowing. Yet the design is such that they give positive protection against dangerous overloads and short-circuit conditions superior to that of any other fuse.

By reducing the number of needless blows BUSS SUPER-LAG Fuses increase operating efficiency. No longer need machines stop, workmen stand idle and production cease because a fuse blew due to short time-lag.

GLANCE AT THE CHART

An indication of what BUSS SUPER-LAG Fuses mean to the user because of their superior time-lag can be seen from the chart on the left which shows how they compare with others. This chart is based upon tests made by the Electrical Testing Laboratories of New York and reported by them on August 25th, 1930. It shows how a 200 ampere 250 volt BUSS SUPER-LAG Fuse compares with other fuses at 100% overload.

30, 60, 100, 400 and 600 ampere sizes show similar results.

YOU BE THE JUDGE

The only true way to judge what the SUPER time-lag of BUSS Fuses will mean to the user is to put the fuses on trial in actual service.

The user who does this will find out-of-service losses decreased and a material reduction in the cost of his fuse protection.

If you would like more complete information about BUSS SUPER-LAG Fuses before trying them in service we will be glad to have a BUSS Representative call on you or send complete data by mail.

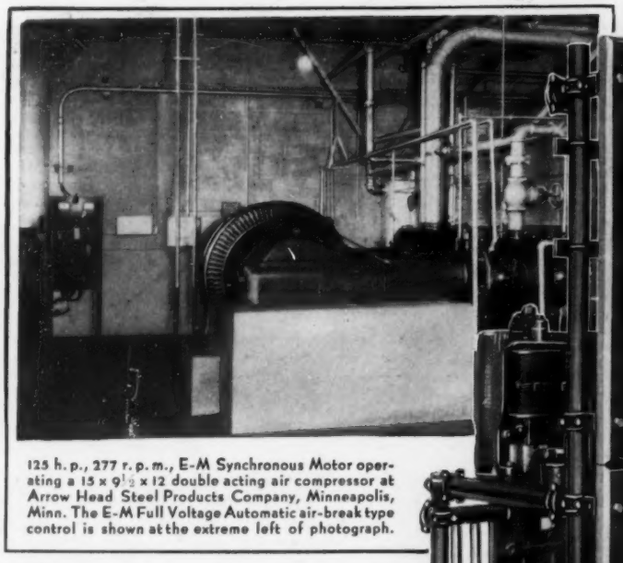
Let us know your preference.

BUSSMANN MANUFACTURING COMPANY, 2536 W. University St., St. Louis, Mo.
A Division of the McGraw Electric Company

THE BUSS SUPER-LAG FUSE

In a Certain Sense,

the Control is as Important as the Motor Itself



125 h. p., 277 r. p. m., E-M Synchronous Motor operating a 15 x 9½ x 12 double acting air compressor at Arrow Head Steel Products Company, Minneapolis, Minn. The E-M Full Voltage Automatic air-break type control is shown at the extreme left of photograph.

EVEN the most efficient motor is handicapped by inadequate starting and control. For that reason, the control assumes importance equal to the importance of the motor. The operation of the motor is so dependent upon the efficient operation of its starting and control device as to virtually make the two a unit.

That is especially true of synchronous motor drives in steel mills and elsewhere throughout the iron and steel industry.

The E-M Automatic Starter for synchronous motors operates responsive to the electrical condition of the motor field winding—a patented E-M feature. It applies direct current to the field at the proper speed to bring about synchronous operation. If a compressor for instance is cold and stiff when started, the E-M Starter will not apply the field excitation until the motor is ready to pull into step.

In case of a momentary power dip or sudden peak load sufficient to cause the motor ta fall out of step, the field "kick-off" relay automatically disconnects the excitation from the motor. Thus the motor is permitted to accelerate and resynchronize immediately.

In such manner does the E-M Starter safeguard and stabilize synchronous motor operation.

E-M Starters are comprehensively described in our 64-page book, *"The Most Efficient Drive in Industry,"* mailed free upon request.

ELECTRIC MACHINERY MFG. COMPANY
Specialists in Apparatus for Power Factor Improvement
1337 Tyler St., N. E., Minneapolis, Minn.
Sales Offices in Principal Cities

This is a full-voltage E-M Automatic Starter, an important factor in the smooth performance of E-M Synchronous Motors. Synchronization is accomplished in the shortest possible time and with a minimum of current inrush and line disturbance. "Frequency-responsive" control, essential element of the E-M Starter, provides speed controlled, permanently correct and trouble-free starting.

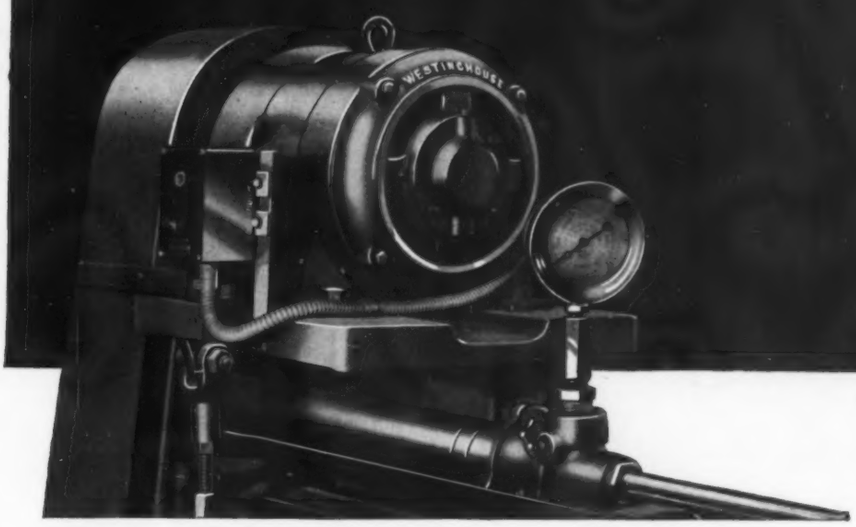
175 h. p., 257 r. p. -, E-M Synchronous Motor operating a 16 x 12 double cylinder air compressor at an industrial plant. E-M Full Voltage, Full Automatic Type Control is used as can be seen in the lower right of photo.

[Users of E-M equipment are assured of quick, reliable service by a corps of trained engineers working out of E-M offices in over 40 cities. The specialized quick-moving E-M factory and sales organization is always ready to give you prompt, skilled attention.]

EM *Synchronous* MOTORS

THE DEPENDABLE, ECONOMICAL DRIVE OF PROVEN PERFORMANCE

Just butter them with grease once a year



Nothing Rolls Like a Ball

IT takes precious little lubricant to keep New Departure Ball Bearing-equipped motors in tip-top running order. Just about a third of a housingful of grease — applied every year or so. And once put in — it is in to stay; sealed in as effectively as dust and dirt are forever sealed out. Shop men like New Departure-equipped motors for their step-saving service. Executives keep buying them because of their cleanliness and dollar-saving dependability. Get behind this nation-wide movement for clean, carefree and economical motors by equipping with New Departures. The New Departure Mfg. Company, Bristol, Connecticut; Detroit, Chicago, San Francisco and London, England.

1647

NEW DEPARTURE BALL BEARINGS

FOR 13 Years TRICO Users Have Enjoyed

. . . Cold facts from enthusiastic users everywhere prove that a distinct and unequalled saving of money is derived from the *Superior Time Lag* in TRICO Fuses—pioneered by TRICO for 13 years.

• •

TRICO *Superior* Time Lag

Here's More Proof that TRICO Superior Time Lag Saves Money

THE consulting engineer of this industrial discarded bare link fuses because of five or six blowouts a week; also two or three burnt-up casings. Six months after the complete installation of TRICO *Superior Time Lag Fuses*, the engineer wrote us that they have not had a single burn-out, and that he had no idea there was such a difference in fuses.

If figures were available regarding loss of production of the 600 men in this plant, each time a bare link fuse had to be replaced, the saving in favor of TRICO would be much higher than shown here.

Comparison

3—600 Amp. 250-volt bare link fuses @ $6.60 each	$ 19.80
130 blows for the period 26 weeks, each blow requiring 4 150-Amp. links, a total of 520 links @ 9c each	46.80
52 casings during 26 weeks *(2 per week)* equals 52 fuses @ $6.60 each	343.20
600 workmen idle. Time out each blow and rate per hour *(don't know)*	? ? ? ?
Total cost *(exclusive of production loss)*	409.80
3—600 Amp. 250-volt TRICO Renewable Fuses @ $6.60 each	19.80
SAVING in favor of TRICO for the 6 months *(exclusive of production gain)*	390.00

(Name on Request)

Approved by Underwriters

ALL in Your Favor

These factors give the reasons why so many users, who insist on money-saving and *dependable* performance, have adopted TRICO Renewable Fuses exclusively.

Money-Saving Factors

No Premature Blowings
No Unnecessary Shutdowns
No Oxidized Contacts
No Charred Casings
Copper-to-Copper Contacts
Reduced Watt Loss
SUPERIOR TIME LAG

And they cost no more than other makes of renewable fuses!

TRICO FUSE MFG. CO., 1006 McKinley Ave., MILWAUKEE, WIS.

TRICO REG. U. S. PAT. OFF. Renewable FUSES

They're "Powder Packed"

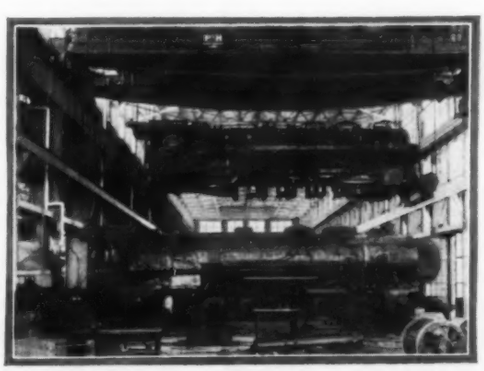
98 P&H CRANES in the Great Eddystone Plant of the BALDWIN LOCOMOTIVE CO.

P&H

P & H Cranes embody superior features—features which assume added value when combined by the world's most experienced crane-building organization. Liberal design. Finest materials. Accessibility of all parts. Extremely fine tolerances. Shafts lift out independently. Gears and pinions, steel with cut teeth running in oil. M.C.B.-type bearings. Meet all safety requirements. Built entirely in P & H Shops—undivided responsibility.

Here is another representative American company that is a large user of P & H Traveling Cranes. Their first P&H Crane was purchased in 1900, and since then, 97 additional P & H Cranes have gone into service in their great Eddystone plant.

This is just another of the leading American plants in which P & H Cranes have been giving satisfactory service over a long period of years.



Left, 250-ton P&H Locomotive-Lifting Crane.

HARNISCHFEGER CORPORATION
(Established 1884)
4455W. National Avenue
MILWAUKEE, WIS.
Offices and Agents in All Principal Cities

A-546

THERE ARE MORE P&H CRANES IN SERVICE THAN ANY OTHER MAKE

Speed Reduction... *integral with the Motor*

NO GEARS NO BELTS NO PULLEYS

TO FULLY appreciate the remarkable economy of weight and space and the high efficiency made possible by the use of the Crocker-Wheeler Speed Changer, study the following comparison of two induction motors.

Parallel Type Reducer Ratio 6:1

Motor *Without* Speed Changer		Motor *With* Speed Changer
10 H. P.	Power	10 H. P.
360 R. P. M.	Motor Speed	1750 R. P. M.
360 R. P. M.	Delivered Speed	360 R. P. M.
1350 lbs.	Total Weight	450 lbs.
13½ inches	Center Height	7⅜ inches
35¾ inches	Length	31 inches
75%	Efficiency	87%
70%	Power Factor	93%

And as you may expect, this small high speed motor equipped with speed changer costs less to buy than the large low speed motor without it.

We will gladly make a similar comparison for you of other size motors. Any predetermined speed reduction may be made within the ratio of 4:1 to 10:1. A Crocker-Wheeler engineer will gladly call and tell you the story of small high speed motors delivering power at low speed . . . with efficiency.

Crocker-Wheeler Electric Mfg. Co.

Ampere, New Jersey

Branch Offices

Birmingham Buffalo Cincinnati Detroit Los Angeles Philadelphia San Francisco
Boston Chicago Cleveland Houston New York Pittsburgh Seattle

CROCKER WHEELER

New Sales and Service Facilities for GREDAG

REG. U. S. PAT. OFF.

• LUBRICANTS

ON November 1, 1930, the sales and service facilities for Gredag Lubricants, well known and long established products of the Acheson Graphite Corporation—a Unit of Union Carbide and Carbon Corporation—were greatly extended.

Gredag Lubricants are now being sold and distributed by the Carbon Sales Division of National Carbon Company, Inc.,—a technical organization which for many years has been in constant contact with industrial plants and distributors of industrial products.

The addition of Gredag Lubricants to the products of the Carbon Sales Division will bring into the lubrication field a force of competent sales engineers familiar with industrial problems. It will also add to the previous facilities five conveniently located Branch Sales Offices and Service Plants.

Please address your inquiries and orders for Gredag Lubricants to the nearest Branch Office of the Carbon Sales Division.

NATIONAL CARBON COMPANY, INC.

Carbon Sales Division

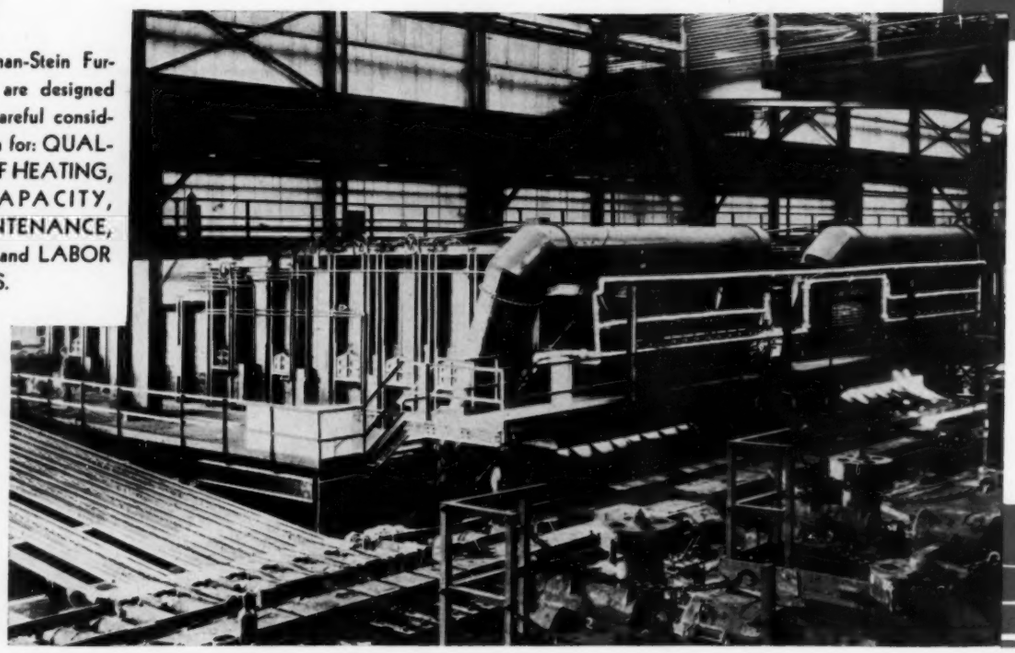
CLEVELAND, OHIO

Unit of Union Carbide and Carbon Corporation

Branch Offices and Factories

NEW YORK · PITTSBURGH · CHICAGO · BIRMINGHAM · SAN FRANCISCO

Chapman-Stein Furnaces are designed with careful consideration for: QUALITY OF HEATING, » » CAPACITY, MAINTENANCE, FUEL and LABOR COSTS.



ANOTHER NEW MILL CHAPMAN

CHAPMAN-STEIN furnaces have been installed on the new 32" strip mill at The Great Lakes Steel Corporation.

These furnaces are fired with fuel oil of very low gravity, and have a capacity of 40 tons an hour. Approximate dimensions of each furnace: sixty feet long by eighteen feet wide.

The complete oil conditioning equipment was engineered and erected by Chapman-Stein. Mechanical atomization employed by the burners eliminates use of steam or compressed air, with a corresponding reduction in maintenance and operating costs.

Construction will soon be started on the furnace for No. 1 Merchant mill at The Great Lakes Steel Corporation. This furnace will also be engineered and installed by Chapman-Stein.

The CHAPMAN
TOLEDO
Division of the Surface Combustion

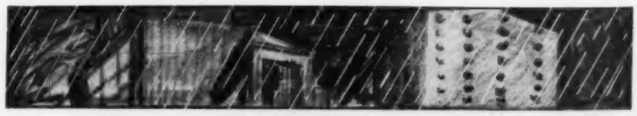
The success of this mill, as with other mills, is largely determined by the furnaces » » so they selected Chapman-Stein.

EQUIPPED WITH STEIN FURNACES

EACH CHAPMAN-STEIN furnace at the Great Lakes mill is equipped with recuperators. Air is preheated to 800° F to 1000 F, which has the advantage not only of bringing about a low fuel consumption, but is essential to proper combustion and ease of control on the heavy oil that is used for fuel.

Either Mantle Metallic Recuperators or Chapman-Stein Refractory Recuperators may be used with due consideration to existing local requirements and conditions.

N-STEIN Co.
OHIO
Co., Incorporated, Dorr St. Toledo, Ohio
SC



Motor control that is independent of weather

THERE'S no need to worry about the placing of equipment if you're figuring on Rowan oil immersed Control.

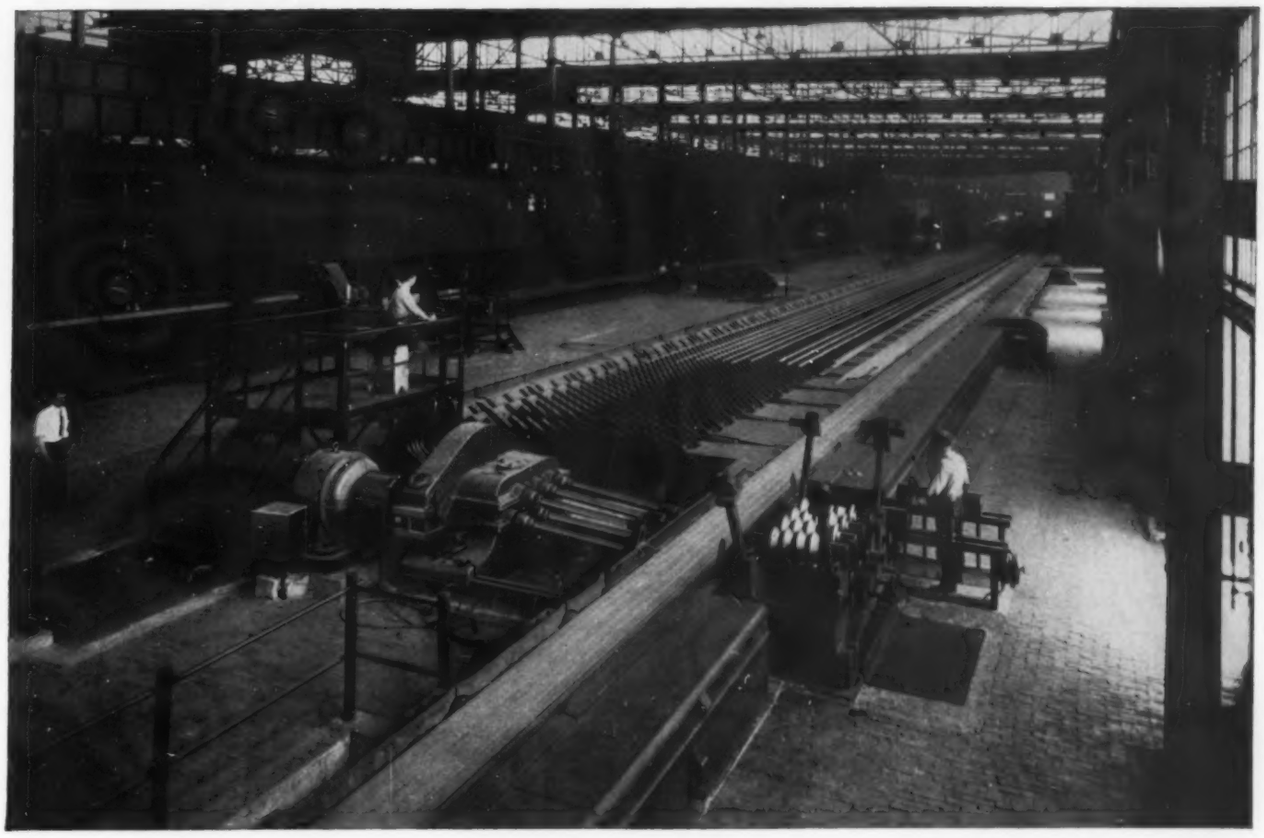
Mount it right out in the weather, if you like; rain, snow or excessive heat have no effect upon its operation. Place it on the wall of the vat room where vapor or corrosive fumes envelop it every day —you can rely upon its dependable performance no matter where it is placed.

Rowan oil immersed Control needs no shelter. Each piece of equipment—safety switch, motor starter, push button—regardless of its size is designed and built to give long, trouble-free service in rough usage under extreme atmospheric conditions. Rowan oil immersed Control is weather proof, dust-tight, vapor proof—ruggedly built for service in plants where uninterrupted operation is imperative and production delays costly.

Bulletins and prices of Rowan Control equipment promptly sent upon request.

ROWAN CONTROL

THE ROWAN CONTROLLER CO., BALTIMORE, MD.



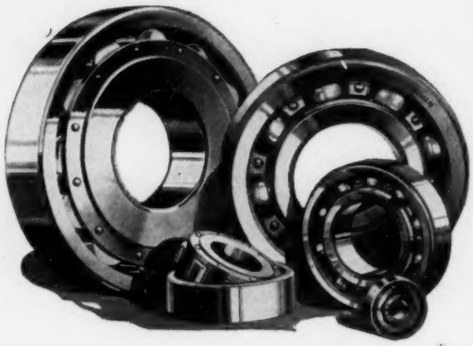
No. 2 Cooling Bed on the 42nd completed Merchant Mill designed and built by Morgan Construction Company and the 159th Mill completely Morgan designed and built. These Cooling Beds are built with machined notches to handle all merchant bar sections, angles and flats, as well as spring bars in packs for annealing, and maintain straightness while cooling.

Morgan Construction Company, Worcester, Mass., U. S. A.

European Representatives: International Construction Company, 56 Kingsway, London, W. C. 2, England — Davy Bros., Sheffield, England

MORGAN
WORCESTER
ENGINEERS AND MANUFACTURERS

PRECISION



FOR BETTER PERFORMANCE

In comparing values, performance should be the determining factor. It is the only true test of worth—gauged not by first cost, but by ultimate cost over a useful life. It is the standard by which true economy must be measured.

In every field of engineering and industry, over a period of twenty years, NORMA-HOFFMANN Precision Bearings have made a distinguished record for dependable stand-up-ability. For greater economy, longer sustained, they stand pre-eminent.

There is a PRECISION Bearing for every load, speed and duty. Let our engineers help you select the type best adapted to your special conditions. And write for the Catalogs.

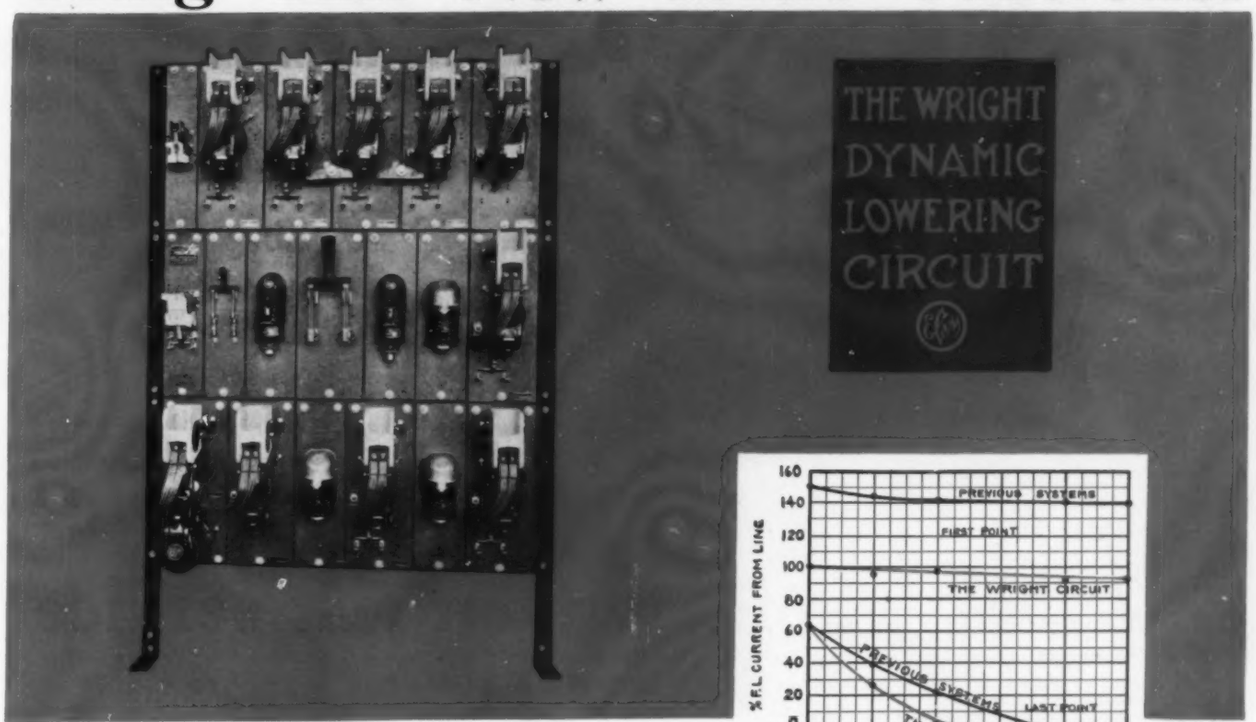
NORMA-HOFFMANN BEARINGS CORPORATION
STAMFORD CONN., U.S.A.

"NORMA-HOFFMANN"
PRECISION BEARINGS

OPEN TYPE BALL BEARING
CLOSED TYPE BALL BEARING
SINGLE ROW SELF-ALIGNING BALL BEARING
PLATE TYPE BALL BEARING
"GREASEAL" BALL BEARING

BEARINGS

Many Crane Owners Benefited By Using This New Hoist Controller

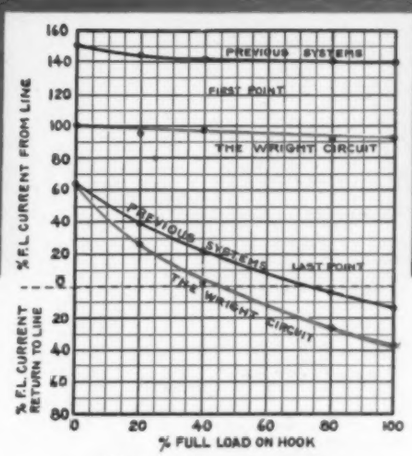


In every prominent industrial center in the United States, EC&M Wright Circuit Controllers are benefiting crane owners. Cranes in the Chicago, Pittsburgh, Cleveland, Detroit, Philadelphia, New York and Birmingham districts are now equipped with this control.

Progressive industrial engineers everywhere are specifying this hoist controller for their crane motors because of such outstanding features as:

1. Instantaneous Release of the Brake,
2. High Speed Lowering of Light Loads,
3. Accurate Spotting of Heavy Loads,
4. Lower Power Consumption.

These are only a few of the advantages of this controller that insure improved crane operation—operation that means more trips per minute with less power consumption. For your direct current cranes, specify the Wright Circuit Controller.



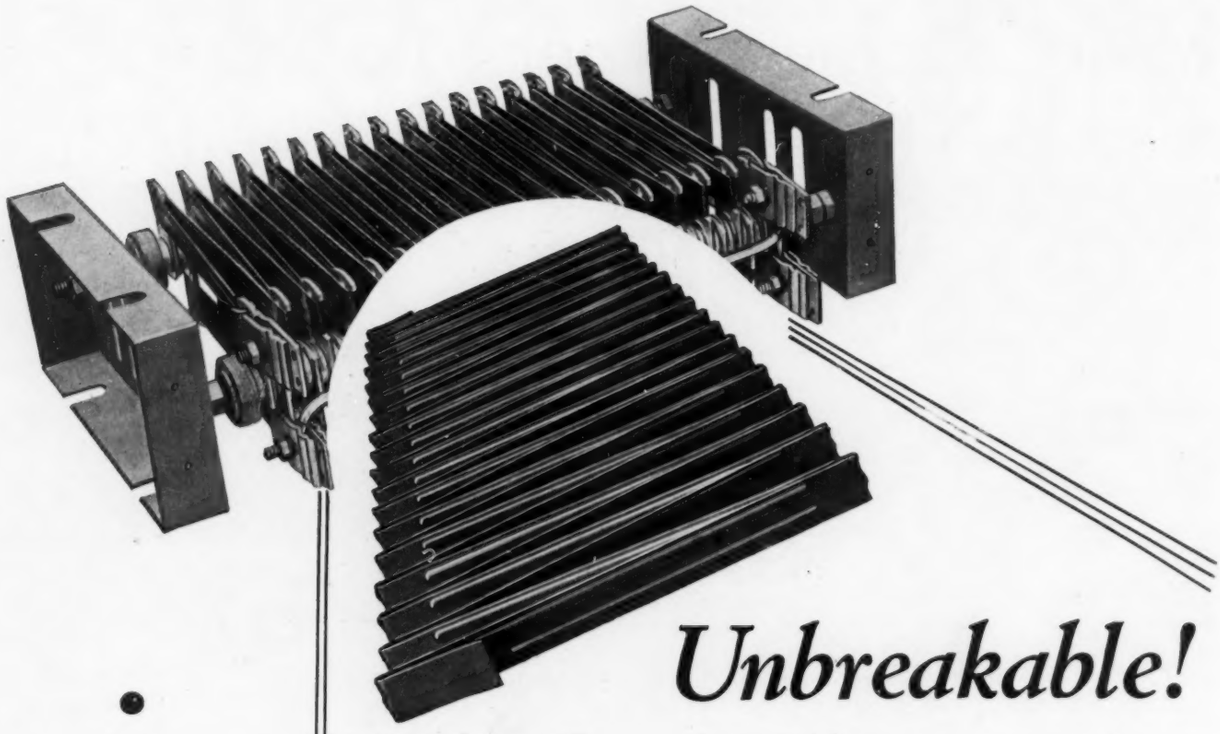
Many Cranes Show Big Power Saving . . .

The above curves show the power saving on one crane. Note that only full load current instead of 150% full load current is taken from the line on the first point lowering. Power on all loads at all speeds is likewise reduced and when lowering overhauling loads, there is a greater return to the line.

On another crane, one hundred trips each with empty hook, half load and full load, showed a total saving of 30% in power for the Wright Circuit.

THE ELECTRIC CONTROLLER & MFG. CO.
CLEVELAND, OHIO

NEW YORK-50 CHURCH ST.
CHICAGO-CONWAY BLDG.
DETROIT-DIME BANK BLDG.
BIRMINGHAM-BROWN-MARX BLDG.
CINCINNATI-1ST NATIONAL BANK BLDG.
ST. LOUIS-6936 MARQUETTE AVE.
LOS ANGELES-912 E. THIRD ST.
HOUSTON-P.O. BOX 4162
TORONTO-REFORD BLDG.
PHILADELPHIA-WITHERSPOON BLDG.
PITTSBURGH-OLIVER BLDG.
SAN FRANCISCO-CALL BUILDING
MONTREAL-CASTLE BLDG.
TULSA-217 E ARCHER ST.
SEATTLE-ALASKA BLDG.



Unbreakable!

built for hardest service

ENGINEERS quickly recognize sound engineering principles. That is why C-H DUR-ristors appeal instantly to men with tough service problems.

The resistor strips of C-H DUR-ristors are made of a flexible, unbreakable alloy and resist jerks, jars and vibration. They are suspended independently of the frame free to expand and contract at will. They are ribbed along the edges so that they won't sag or warp and all expansion and contraction must take place lengthwise. They are directly exposed to the air at all points so heat dissipates freely.

All brittle material has been eliminated. Mica insulation is used. The end-frames are of sheet steel, the supporting bars of heavy steel. Terminal lugs are through-bolted over the resistance-strips to the frame. The entire DUR-ristor is rust-proof and non-corrodible.

DUR-ristor is so light in weight that it can be carried under the arm. All DUR-ristors are of the same dimensions and compact, facilitating standardization of resistor-banks.

Send for a descriptive folder.

Only C-H DUR-ristors provide all these advantages

1. *Two continuous sections of resistor strip entirely independent of supporting frame, assuring freedom for expansion without interference.*
2. *Resistor strip proportionally ribbed to prevent warping or sagging—supported at ends only, permitting expansion or contraction.*
3. *No series contacts—continuous metal circuit through each section. Taps are clamped with through-bolts directly over grid strip to supports, as required—making convenient wiring.*
4. *Cool connections—taps taken at turning edges.*
5. *All mica insulation.*
6. *Free ventilation. No material inside of or around strip to interfere with free dissipation of heat to atmosphere. Comparatively low operating temperature.*
7. *Non-corrodible alloy strip—all steel supports cadmium-plated. Entire unit rust-proof. Permanently neat appearance.*
8. *Adaptable—standardized unit mill frames. Rectangular shape more flexible.*
9. *Dimensions for steel mill duty—22¼x5½x11⅛ inches.*
10. *Weight for steel mill duty—20-30 lbs. net, depending on ampere rating.*

CUTLER-HAMMER, Inc.
Pioneer Manufacturers of Electric Control Apparatus
1264 St. Paul Avenue - Milwaukee, Wisconsin

CUTLER HAMMER

DUR-ristor···Durable Unbreakable Resistor

(A-292)

MARTINDALE *Shop-Type* UNDERCUTTER and ARMATURE STAND

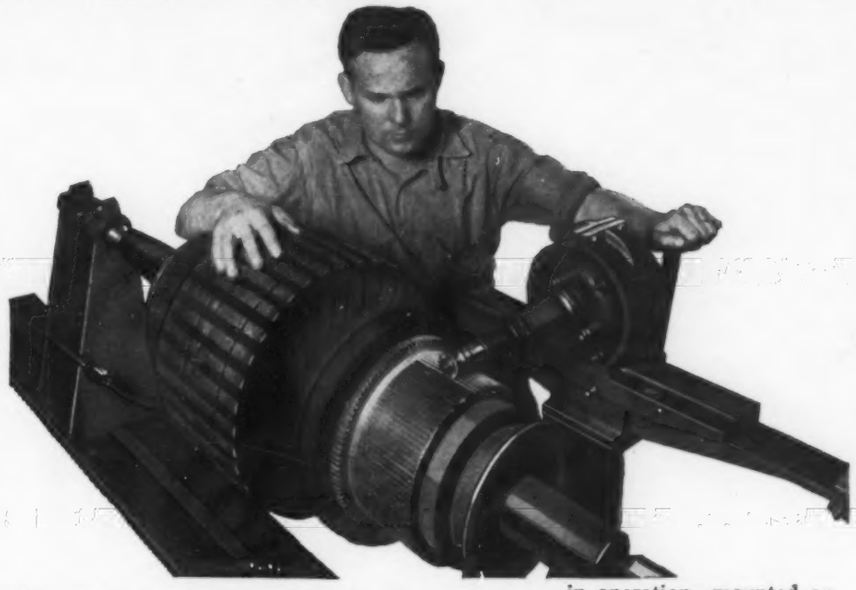
"BUILT LIKE A BATTLESHIP"

Especially adapted for undercutting commutators in shops where it is customary to pull the armatures out of the motors for overhauling.

Sturdy *construction*

Accurate *work with speed*

Speedy *performance with accuracy*



Adjustable *to varied conditions*

Positive *in action*

Direct-Drive *without belt and pulley complications*

Martindale Shop-Type Undercutter in operation—mounted on Martindale Armature Stand.

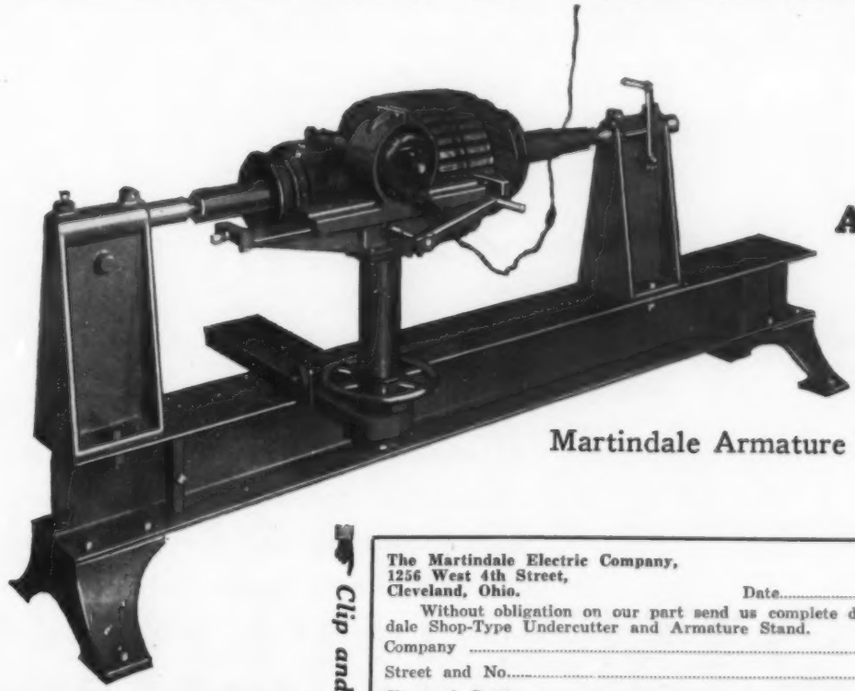
SOLD ON TEN DAYS' APPROVAL

(During the past four months, four Service Stations of the large Generator and Motor Manufacturers have purchased this Undercutter. Also, one of the largest Electric Railway Shops in New England has installed four of these machines.)

SHIPPED ANYWHERE IN U. S. A. ON APPROVAL—NO OBLIGATION TO BUY.

Freight prepaid to destination. May be returned freight collect if not adapted to your shop undercutting needs.

Husky



Adjustable

Martindale Armature Stand

THE MARTINDALE ELECTRIC CO.
1256 W. 4th St., Cleveland, Ohio, U.S.A.

Clip and Mail

The Martindale Electric Company,
1256 West 4th Street,
Cleveland, Ohio. Date.....

Without obligation on our part send us complete details on the Martindale Shop-Type Undercutter and Armature Stand.

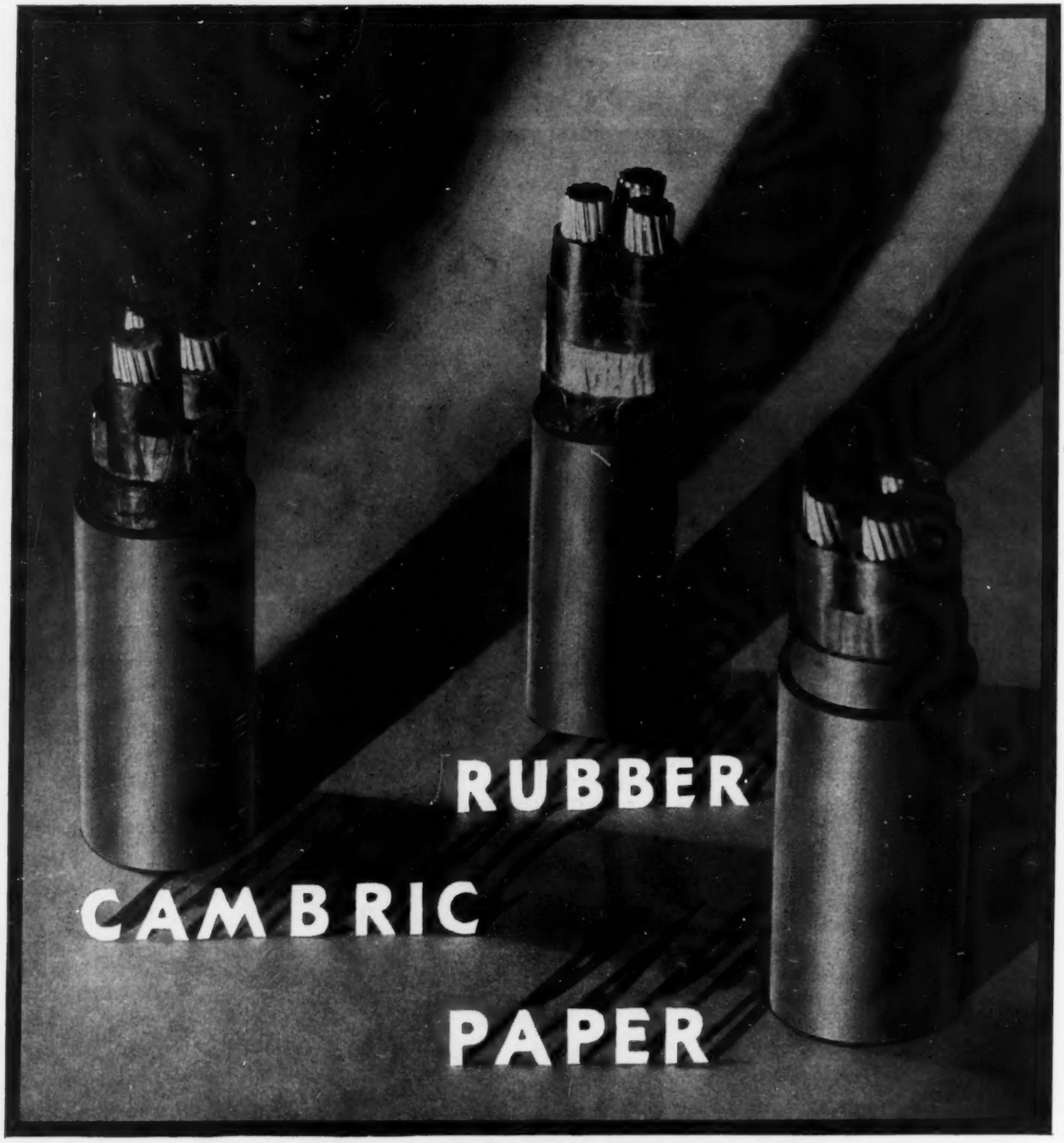
Company .....

Street and No.....

City and State.....

Individual..... Title.....

12-30



Aerial, underground, submarine—every type of power cable, for transmission or distribution circuits. Exceptional facilities in plants, men and experience are behind the splendid year-in year-out performance of Safety Power Cables. Expert engineering cooperation is always extended, gladly.

GENERAL CABLE CORPORATION

EXECUTIVE OFFICES: 420 LEXINGTON AVENUE, NEW YORK • OFFICES IN PRINCIPAL CITIES

"Consider me first! —there's no reason why you shouldn't"

C-H holding, closing-line and trolley-master drum controllers on C-H Ltl Control in crane-cab of ore-bridge at the Buffalo Union Furnace Co., Buffalo, N.Y.

THE operator of steel-mill equipment works best, produces most, when he has made operation of his equipment a habit. And habit develops only when the response to the controller is uniform, duplicated, always in the same way and at the same time.

There is no reason why you should not consider your operator first and select a Control which accelerates *all* loads alike.

Cutler-Hammer *L*tl Control provides that uniform, habit-making, highly productive acceleration of *all* loads. There is no racing on light loads, no lagging on heavy. Current is kept low on the first two steps, easing the load into motion instead of *smashing* it into action. "Pressure" is applied on the last steps . . . *after* the load is moving. The motor is given an exceptional degree of protection against dangerous overloads.

There are no dashpots or relays on the accelerating circuit: this absence of relays and moving parts simply results in increased service without trouble.

The part a control-system plays in production makes the C-H *L*tl Control worthy of full investigation. Send for a copy of the booklet *"Steel Must Never Stop"* describing C-H *L*tl Control.

CUTLER-HAMMER, Inc.
Pioneer Manufacturers of Electric Control Apparatus
1269 St. Paul Avenue
MILWAUKEE : WISCONSIN

CUTLER HAMMER

C-H

The Control Equipment Good Electric Motors Deserve

(A-245)

LARGEST BUILDERS OF THE WORLD'S LARGEST CRANES

Alliance Products

STANDARD CRANES
Up to 430 tons capacity

STRIPPING CRANES
Up to 320 tons capacity

COMBINATION CHARGERS and STRIPPERS
Up to 200 tons capacity

- Ladle Cranes
- Ingot Strippers
- Soaking Pit Cranes
- Open Hearth Charging Machines
- Slab and Billet Charging and Drawing Machines
- Gantry Cranes
- Ore and Coal Bridges
- Car Dumpers
- Forging Manipulators
- Steam Drop Forge Hammers
- Coke Pushers, Levelers and Door Lifters
- Coal Pier Equipment
- Rolling Mill Machinery
- Cement Plant Machinery
- Dock Handling Equipment
- Coke Oven Equipment

271 of 100 Tons Capacity and over

LADLE AND STANDARD CRANES

59		100 tons
2	WORM DRIVEN Ladle,	100 tons
2		115 tons
6	WORM DRIVEN Ladle,	125 tons
45		125 tons
30		150 tons
3	WORM DRIVEN Ladle,	150 tons
6	WORM DRIVEN Ladle,	160 tons
2	WORM DRIVEN Ladle,	165 tons
4	WORM DRIVEN Ladle,	175 tons
27		175 tons
3	WORM DRIVEN Ladle,	200 tons
4		200 tons
5		225 tons
1		250 tons
3	WORM DRIVEN Ladle,	250 tons
3	WORM DRIVEN Ladle,	275 tons
1		275 tons
1		300 tons
3		430 tons

STRIPPING CRANES

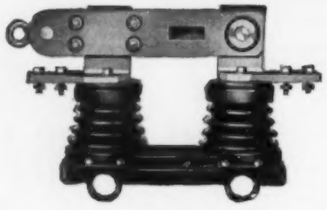
8		100 tons
1		125 tons
21		150 tons
19		200 tons
1	Single Ram,	320 tons

COMBINATION CHARGERS AND STRIPPERS

3		100 tons
1		125 tons
3		150 tons
4		200 tons

Give Us the Runway and We will Lift the World

THE ALLIANCE MACHINE CO.
ALLIANCE, OHIO, U.S.A.
ENGINEERS AND BUILDERS



Cat. No. 10497-Z Type U-1
7500 Volts 1200 Amperes

Cat. No. 12583-Z Type W-7
7500 Volts 300 Amperes

SERVICE VALUE

After all, it is the "service value" of electrical equipment that counts and not the original cost. The highest service value can only be obtained from equipment built to withstand the most severe service that can be applied to it. By being well designed by men who know operating conditions, by being constructed of the best materials obtainable and finally, assembled by men who know their job, Three E equipment has service value built into it.

Three E indoor disconnecting switches have numerous features which make them profitable investments in service value. May we send you our Bulletin No. 112 which fully explains these features?

SERVICE VALUE—Low Cost per Year of Service

It pays to use The Three E' Catalogue

ELECTRICAL ENGINEERS EQUIPMENT CO.

General Offices and Factory:
MELROSE PARK, ILL.

Sales Offices in All Principal Cities

Canadian Representative
Northern Electric Company
LIMITED

"THREE E"
HIGH QUALITY
LINE AND STATION EQUIPMENT

Standard Speeds for Both
Electric Motor and Centrifugal Gas Booster
THE use of the DE LAVAL DOUBLE HELICAL GEAR as a speed increaser between the 750 rpm. motor here shown driving a DE LAVAL MULTISTAGE CENTRIFUGAL GAS BOOSTER of 16,650 cu. ft. per min. capacity, against 7 lbs. pressure, results—
1—In economy of first cost of both compressor and motor,
2—In high efficiency for motor and compressor,
3—In smooth and quiet operation, and
4—In reliability.
De Laval gears are built for all powers and speed ratios, and De Laval compressors for all capacities and for pressures up to 100 lbs. per sq. in.
DE LAVAL
DE LAVAL
De Laval Steam Turbine Co., Trenton, N.J.
3174
3062

132,000 Volt
Moloney Transformer.

THE liberal mechanical and electrical design of MOLONEY transformers insures their satisfactory performance under all operating conditions.

MOLONEY ELECTRIC COMPANY
ST. LOUIS, MO.

MOLONEY TRANSFORMERS

HOLOPHANE

THE LIGHTING EQUIPMENT OF

FAME

— FOR —

Steel Mills - Foundries - Yards

— SOLD BY —

RUMSEY

Electric Company

Electric Supplies, Machinery and Radio

1007 ARCH STREET

PHILADELPHIA

SHAW *Electric Traveling Cranes*

The Billet Yard Crane

A Shaw Mill Crane in your billet yard is the best insurance of continuous and efficient operation. The traditional Shaw Crane Workmanship not only means low maintenance cost, but also uninterrupted Crane Service.

Manufactured at

SHAW CRANE WORKS, Muskegon, Mich.

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MANNING, MAXWELL & MOORE, INC.

BUSS SUPER-LAG FUSES

The Greatest Scientific Improvement Ever Made in Fuses

A FUSE TO KEEP YOUR PLANT OPERATING—
NOT JUST TO PROTECT YOUR EQUIPMENT

See Announcement Page 603

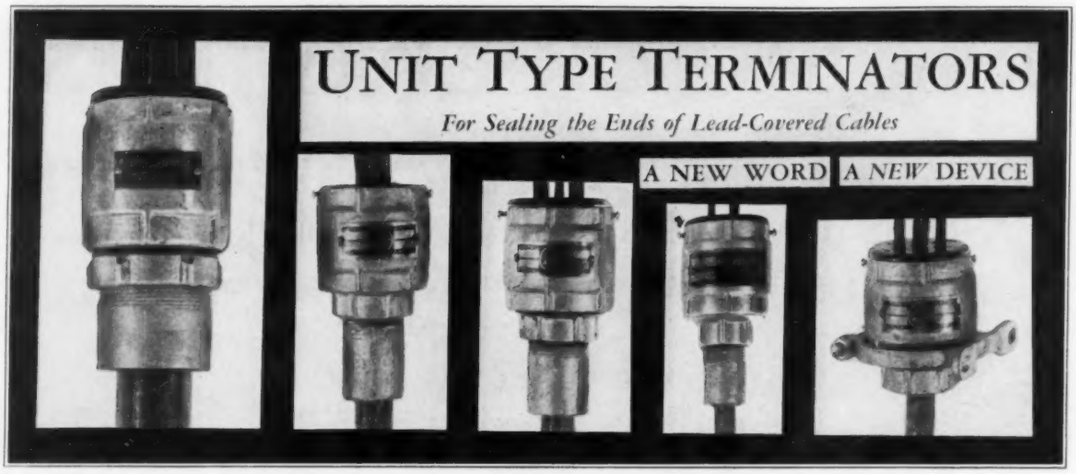
WE HAVE THEM

A Complete Stock to Serve Your Fusing Needs

DOUBLEDAY-HILL ELECTRIC CO.

110-112 SEVENTH STREET PITTSBURGH, PA.

DeLaval Worm Reduction Gears
THIS metal forming machine, built by Dienelt & Eisenhardt, Philadelphia, fabricates 36 in. 10 gage metal into cornice molding, etc. at the rate of 65 ft. per min., but occupies only 22½ x 8½ ft. The 12 rolls are driven by 4 De Laval 17½ ratio top drive worm reduction gears, which receive power from a 175 hp., 860 r.p.m. motor through a De Laval 2.03 ratio helical gear. The worm wheel shafts are extended on both sides to permit of doubling the capacity by adding another set of rolls.
Economize SPACE
De Laval Steam Turbine Co., Trenton, N. J.



"PB" Terminator

This Terminator is the result of co-operative effort of many cable users and our Research Laboratory Engineers. It is mechanically strong, electrically safe, easily installed and meets the economic demand for a reasonably priced device. Ask for Bulletin 65-A.

"PB" Terminator

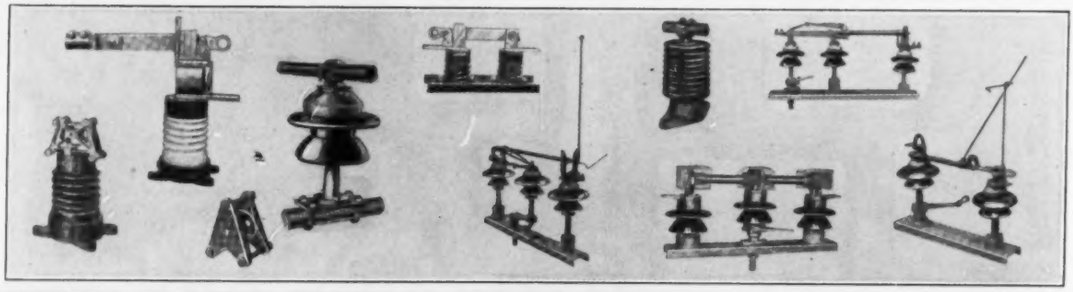
MAKERS OF
Delta UNIT TYPE EQUIPMENT Star

DELTA-STAR ELECTRIC COMPANY, 2400 BLOCK, FULTON ST, CHICAGO, ILLINOIS.

"Service for the Years to Come"

FOR your immediate requirements in 1931, you can afford nothing less rugged, less dependable than R. & I. E. Equipment. Twenty years of service to the industry is the basis of R. & I. E. Standard of Quality.

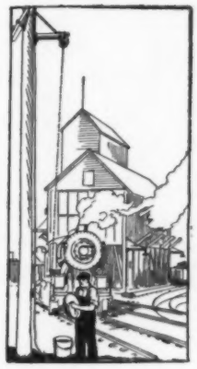
Look it up first in the R. & I. E. Catalog.

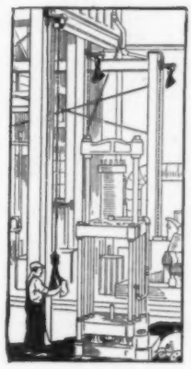


RAILWAY AND INDUSTRIAL
ENGINEERING CO. . . . . GREENSBURG, PA.

SALES OFFICES:
Cleveland, Buffalo, Chicago, Cincinnati, Philadelphia, St. Louis
Denver, Pittsburgh, Birmingham, Charlotte, Boston, New York

A Clean Reflector is a Worker—
—A Dirty Reflector is a Loafer





Somebody says:

"The purpose of a reflector is to put the light where you want it."

But a dirty reflector will not put the light anywhere—it will do about as much good as an old black hat hung over the bulb.

THOMPSON
SAFETY LOWERING SWITCH
or HANGER

Solves the lamp-cleaning problem, because it enables the work to be done with **ease** and **safety** down on the ground—no climbing hazards—no electrical hazards, for the lamp is lowered away from the electric circuit for the cleaning process. The advantage is obvious.

In use in railroad shops and yards, steel mills, foundries, machine shops, cement plants, paper mills, ore and coal docks, armories and countless other places—because they help to make reflectors pay.

Inexpensive and easily included in present lighting systems.

As the cost of all lighting equipment is insignificant compared with the value of the light in carrying on the industry, is it not reasonable to make the installation complete enough to enable it to accomplish its purpose and give the maximum results continuously?

Get Catalog B-26 for the details.

The Thompson Electric Co.
1438 W. 9th St. Cleveland, Ohio, U. S. A.

IN ADDITION TO

Marked Efficiency

WITH THE USE OF

"LE CARBONE"

CARBON BRUSHES

YOU WILL OBTAIN

Economies

THAT WILL SURPRISE YOU

✣✣

"They talk for themselves"—

✣✣

Le Carbone Co.

W. J. JEANDRON, Manager
Fifteenth and Bloomfield Streets,
HOBOKEN, N. J.

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San Francisco—829 Rialto Building
W. R. Catching, Sales Engineer

CANADIAN DISTRIBUTORS

Lyman Tube & Supply Co.—Montreal and Toronto

GURRUM

In the Orient when a bunch of the fellows get together for a feast, they immediately start complaining of the heat (gurrum), and peel off one garment after another.

The real reason, however, is not the heat, but rather to show what gorgeous underthings they possess.

A Morganite representative sends in this custom with the note: "I have often wished I could practice a similar method when displaying the Morganite brush to an assemblage. If I could strip the brush down to its essentials and show the high quality of its make-up—they could more readily understand the added service Morganite brushes provide. I myself would be afraid to follow suit, or in other words, it's not the heat (gurrum) but the timidity."

Morganite Brush Co., Inc.

Main Office and Factory
3302-3320 Anable Ave., Long Island City, N. Y.

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Pittsburgh, Electrical Engineering & Mfg. Co., 909 Penn Ave.
Cleveland, Electrical Engineering & Mfg. Co., 320 Union Building
Birmingham, Ala., A. J. Bowron, 1210 Watts Building
Los Angeles, Electrical Engineering Sales Co., 502 Delta Bldg.
Revere, Mass., J. F. Drummey, 62 Pleasant Street
San Francisco, Electrical Engineering Sales Co., 222 Underwood Bldg.
Toronto, Can., Railway & Power Engineering Corp., Ltd., 171 Eastern Ave.
Montreal, Can., Railway & Power Engineering Corp.,Ltd., 898 St. Antoine Street
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IRON CITY ELECTRIC CO.

Westinghouse Agent Jobbers
The House That Service Built

The House Built For Service

Cor. Sixth Ave. & Diamond St. (Near Forbes Street) Pittsburgh, Pa.

DISTRICT FOR THE FOLLOWING LINES

Westinghouse Safety Switches
" " " Lighting Equipment
" " " Panel Boards
" " " Motors and Controls
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" " " Lightning Arresters
" " " Insulating Materials and Other Supplies
" " " Mazda Lamps
" " " Fans
Erie Malleable Kondu Boxes
Crouse Hinds Condulets
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Rome Super Service Cords and Cables
Beaver Stocks and Dies
Hubbard Pierce Pole Line Specialties
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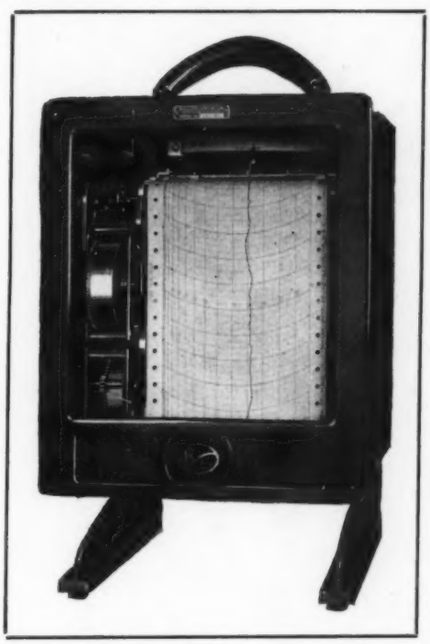
AND ALL KINDS OF ELECTRICAL SUPPLIES FOR INDUSTRIAL PLANTS, FACTORIES and MINES

Just Seven Months Ago

ROLLER-SMITH *Announced* GRAPHICS



In the short time since then the many outstanding features of this new line have been recognized and appreciated by many very particular engineers and large numbers of R-S Graphics are giving fine service under all sorts of trying conditions.

The line comprises switchboard, portable and wall models, A.C and D.C., ammeters, voltmeters, wattmeters, power-factor meters and special devices for special applications.

Send for your copy of Bulletin No. AK-830.

Forty years' instrument experience in back of

ROLLER-SMITH COMPANY

Electrical Measuring and Protective Apparatus

MAIN OFFICE
2131 Woolworth Bldg., NEW YORK

WORKS
Bethlehem, Penna.

Offices in principal cities in U. S. A. and Canada

YOU'LL HAVE NO BRUSH PROBLEMS *with*

USG

BRUSHES

U. S. G. Brushes are "Tailor-made"—especially manufactured to meet the specific requirements of your motors and generators. All are sold under a guaran tee—made possible by U. S. G. satisfactory performance and efficiency.

Our engineers will make it easy for you to get perfect brush service. May we send one to discuss your brush situation?

THE UNITED STATES GRAPHITE COMPANY

SAGINAW, MICHIGAN, U. S. A.

NEW YORK PHILADELPHIA PITTSBURGH ST. LOUIS CHICAGO

PUT IT UP TO HAGAN ENGINEERS

Just name your objective in Heat Treating and Hagan Engineers will design the furnace that will successfully accomplish it—whether it be for Forging, Hardening, Carburizing or Annealing—Large Production or Small—Automatic or Semi-Automatic.

Hagan Engineers are always ready to cooperate with you.

GEORGE J. HAGAN COMPANY

PITTSBURGH, PA.

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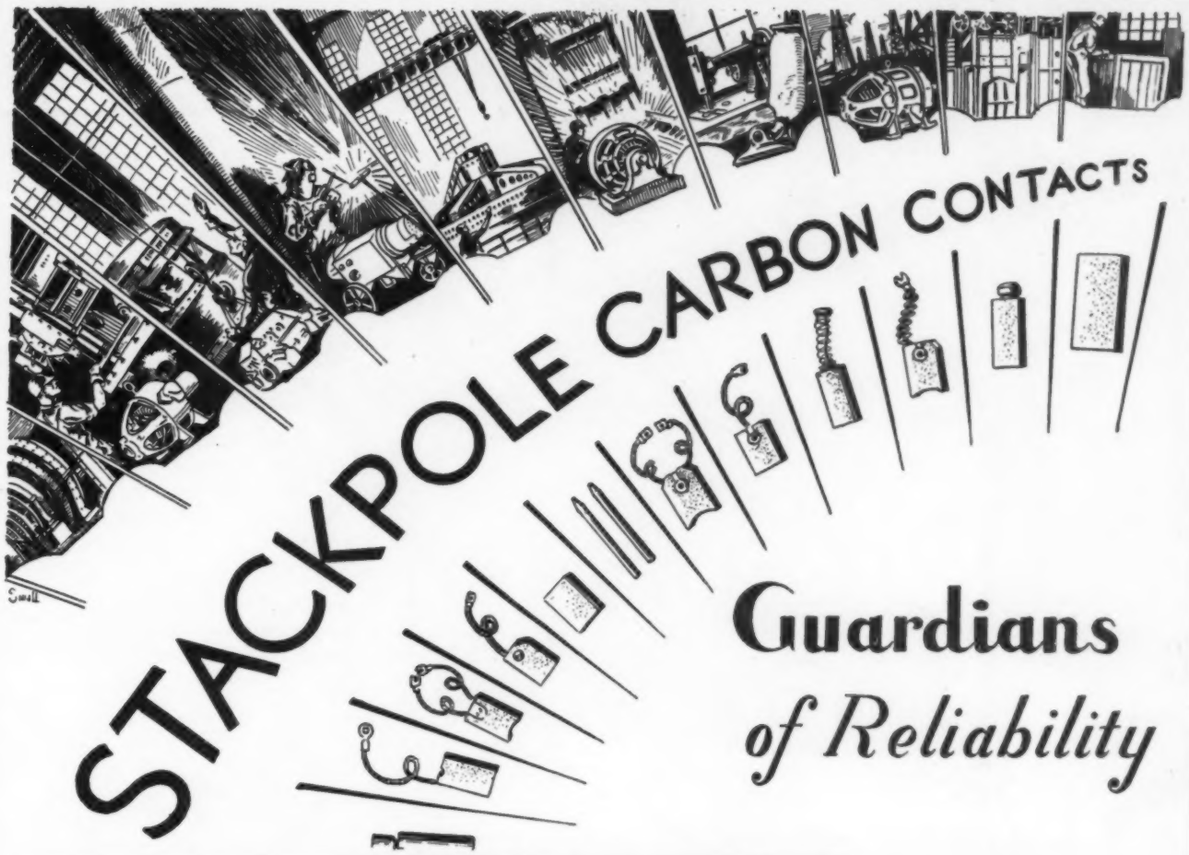
20 E. Jackson Blvd.

DETROIT
155 W. Congress St.

SAN FRANCISCO
273 Seventh St.

HAGAN
Industrial Furnaces



Guardians *of Reliability*

Successful Stackpole Brush and Contact Grades

TRACTION—L-30, L-31,B-22
ROTARY CONVERTER
DC end—B-22, M-57
AC end—S-83, 933
DC INDUSTRIAL MOTORS
L-21, L-30, S-11
MINE MOTORS
L-30, S-11
MILL MOTORS
L-30, S-11
SWITCH METAL GRAPHITE CONTACTS
S-81, S-86
SLIP RING INDUCTION MOTORS
S-86, A-10

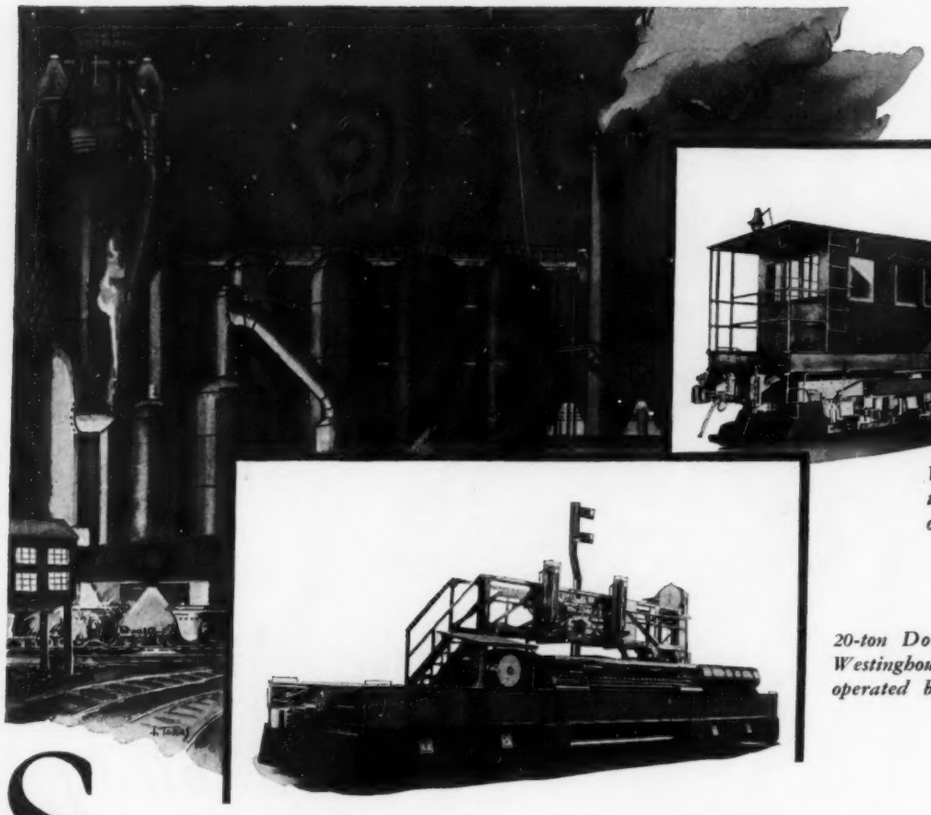
Stackpole Brushes and Contacts are giving outstanding service on—

ROTATING ELECTRICAL MACHINERY
SWITCHES
CIRCUIT BREAKERS
WELDING MACHINES
ELECTRIC FURNACES
ELECTROLYTIC CELLS
AUTOMOBILE STARTERS
LIGHTING GENERATORS
FRACTIONAL H. P. MOTORS
THERAPEUTIC CARBONS

Let Stackpole Help to Solve Your Contact Problems

Representatives in the following cities: Boston, Chicago, Cleveland, Detroit, Havana, Huntington, Indianapolis, Los Angeles, New York City, Philadelphia, Pittsburgh, Rochester, San Francisco, Seattle and Toledo. *Write for the address of our nearest representative.*

STACKPOLE CARBON COMPANY - ST. MARYS, PA.



Photos by courtesy of The Atlas Car & Mfg. Co., Cleveland, Ohio.

Westinghouse-equipped, 150-ton, three-compartment, side dump ore transfer car in steel mill operation.

20-ton Double-compartment, Westinghouse-equipped scale car operated by The Inland Steel Company.

SAVING DOLLARS
on Mill Handling Material

MANY of the world's foremost iron and steel companies have found that Westinghouse-equipped scale and transfer cars have greatly reduced the expense of handling mill materials.

These reductions are effected by the movement of larger volumes of tonnage at lower operating and maintenance costs.

Ruggedly built to withstand the gruelling requirements of mill material haulage, these cars operate on standard gauge track and have motor equipment capable of hauling trailer cars when necessary.

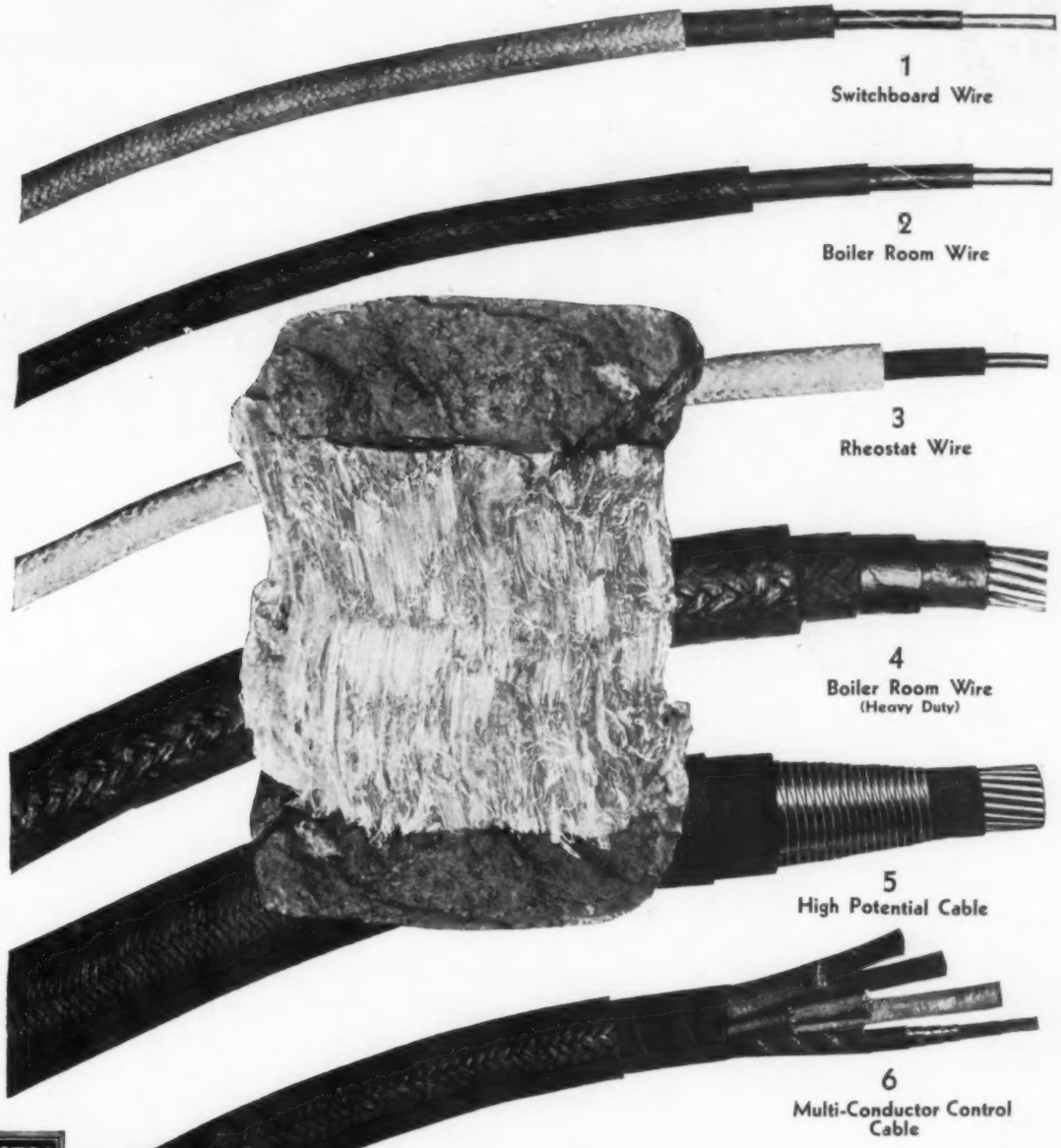
Service, prompt and efficient, by a coast-to-coast chain of well-equipped shops

Westinghouse

T 31613

TUNE IN THE WESTINGHOUSE SALUTE OVER THE N. B. C. NATION-WIDE NETWORK EVERY TUESDAY EVENING.

Does Permanent Insulation interest you?



These Rockbestos wires and cables with permanent insulation are the result of the combined effort of industrial engineers cooperating with Rockbestos engineers.

Actual use and performance in many iron and steel mills has thoroughly justified this cooperation.

Each wire is built for a specific purpose, and use and experience with it, has proven it the best obtainable for that purpose.

If you are interested in these wires and cables with permanent insulation, send for our Bulletin No. 10.

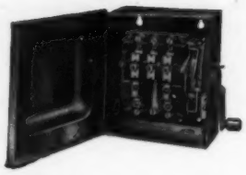
ROCKBESTOS PRODUCTS
CORPORATION
398 NICOLL STREET
NEW HAVEN, CONN.

5942 Grand Cent. Term. Bldg., New York
903 Clark Bldg., Pittsburgh, Pa.
718 Madison Term. Bldg., Chicago

ROCKBESTOS

—the wire with permanent insulation

2019 Railway Exch. Bldg., St. Louis, Mo.
On the Pacific Coast—Anaconda Wire & Cable Co.



Type "T.M.—7½" Motor Starting Switch with Thermostatic Overload Protection.

Type "A" Safety Switch with "Snuf-Arcs" for 575 V. Service.

THE RIGHT SWITCH *for the job - - - -*

Type "M-7½" Magnetic Motor Starting Switch with Overload and Low Voltage Protection.

Type "T-T." Thermostatic Tumbler Switch for Controlling Fractional H.P. Single Phase Motors. Overload Protection is Provided.

Modern industrial needs call for specialized switches for individual requirements. The importance of using the correct type of switch cannot be over-estimated. That a switch has been approved by the Underwriters' Laboratories does not mean that it is most suitable for the purpose for which it is used.

Thirty years' experience and research enables the makers of the "Circle T" Line to offer you a complete range of switches. Each switch built for its job, and even more than that. Each one built with a sturdiness that means thorough reliability.

Our Experimental Department and Laboratory, fully equipped with experienced research engineers, is constantly seeking for better and more efficient methods. They are working for you. Put your switching problems up to them.

We would like to send you copy of our catalog No. 14 . . . . . you will find it a complete and handy reference book of electrical protection and control.

Sold Through Wholesalers

The TRUMBULL ELECTRIC MFG. CO.

Plainville, Connecticut

Branch Switchboard and Panelboard Factories: Ludlow, Kentucky
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803 Lincoln Bldg.
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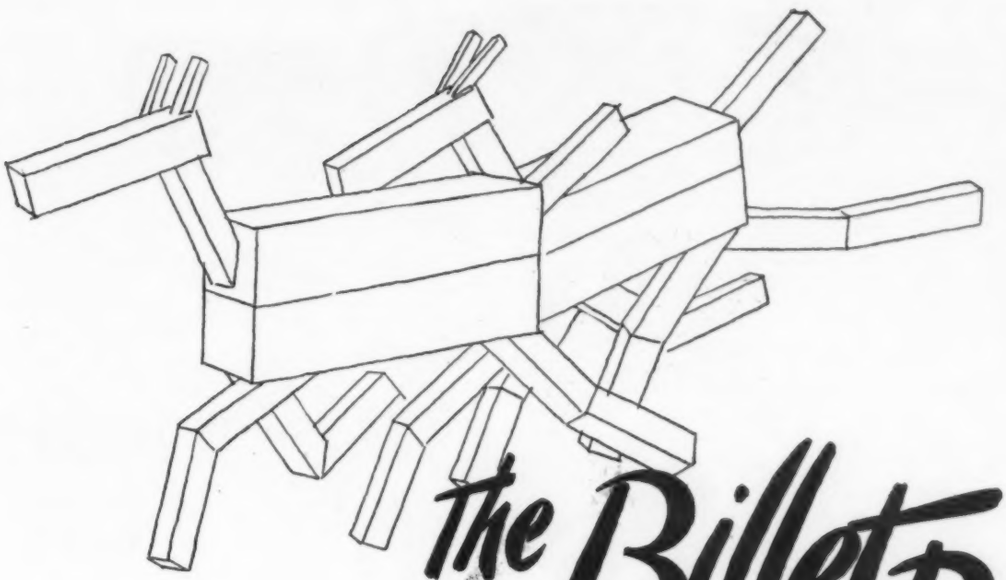
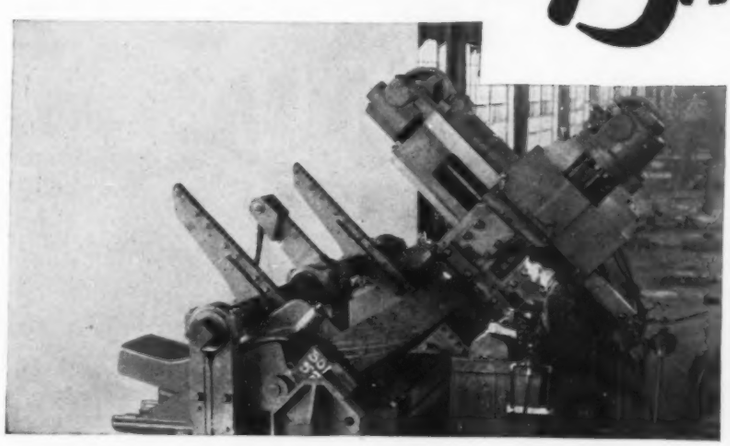
DETROIT Branch
415 Brainard St.

A. G. Electric Mfg. Co. Division Branch Switch, Switchboard and Panelboard Factories—Los Angeles—Seattle

A GENERAL ELECTRIC ORGANIZATION



The Billet Race



One man does more and better work than an army of hand chippers.

WHICH do you bet on . . . billet production where hand chipping handicaps as to cost, speed of output and labor conditions, or on production which employs the Putnam Billet Gouger to peel or gouge billets . . . where a modern production tool with one man does more and better work than a small army of hand chippers?

The Putnam Billet Gougers are no longer an experiment. They are working in actual production. Cost studies in different plants showing savings in direct labor better than sixty cents per ton. Figures and results are so startling that the steel men cannot afford to overlook them.

We invite your careful investigation of machines working in plants with problems similar to yours. Further information will be gladly furnished.

Special Production Machinery for Steel Mills

Billet Peelers

Squaring and Slitting Shears for Metal Sheet Mills

Heavy Duty Machine Tools for Industrial Use

Special Purpose Machinery

Manufactured at

PUTNAM MACHINE WORKS, Fitchburg, Mass.

Owned by

MANNING, MAXWELL & MOORE, Inc.

General Offices: 100 East 42nd St., New York City

Branches: *Chicago* *Detroit* *Philadelphia* *St. Louis*

Representatives:

Arch Machinery Co.
1005 Park Bldg., Pittsburgh, Pa.

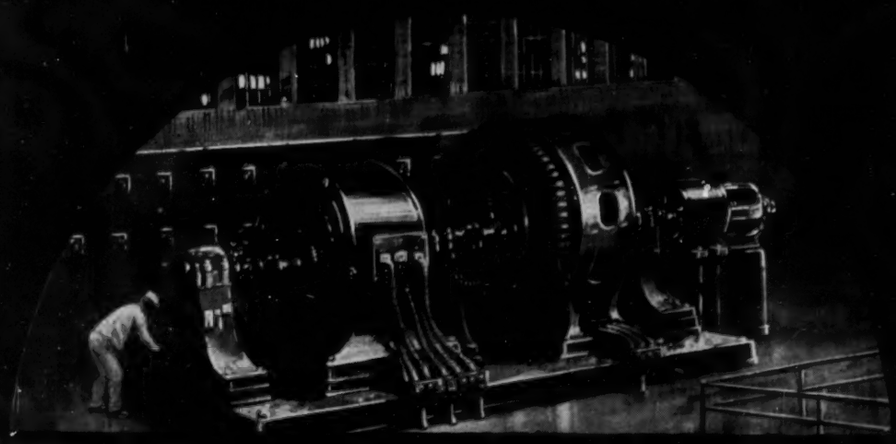
International Equipment Co., Ltd.
Royal Bank Bldg., Montreal, Canada

Smith-Booth-Usher Co.
228 Central Ave., Los Angeles, Cal.

Herberts-Moore Machinery Co.
140 First St., San Francisco, Cal.

The Putnam Billet Gouger is now offered in sizes capable of handling billets to 30 feet long, all cross sections, all steels from low carbon to high speed. No more material is wasted than in hand chipping.

MANNING, MAXWELL & MOORE, Inc.



ECONOMY *renewable* FUSES

INDUSTRIES using electrical energy save 80% annually in fuse maintenance costs when they install Economy renewable Fuses in the place of "one-time" fuse-equipment.

Economy Fuse performance is a matter of record—they were the first fuses using inexpensive bare renewal links for restoring blown fuses to their original efficiency to be *Approved in All Capacities* by the Underwriters' Laboratories.

Economy "Drop-Out" Renewal Links cost but little and make the restoration of a blown fuse the work of a moment only.

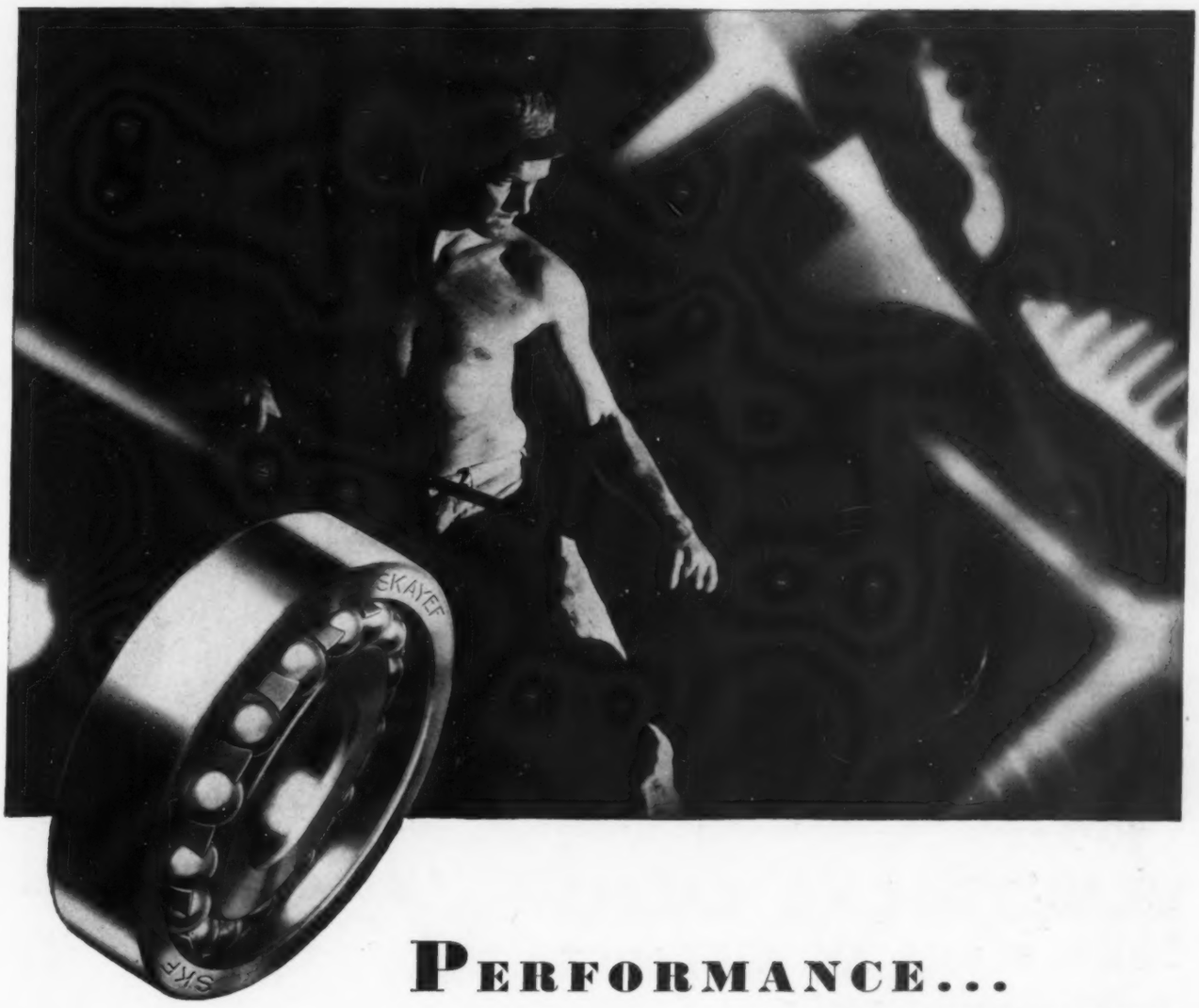
Your plant needs Economy Fuses. Investigate the quality of the electrical protection you now have from the standpoint of dependability, efficiency and economy.

Then order Economy Fuses installed.

For Sale by all leading Electrical Jobbers and Dealers.

ECONOMY FUSE & MFG. CO., Chicago, U. S. A.

Economy Fuses are also made in Canada at Montreal



PERFORMANCE...
that's it... PERFORMANCE
...in a Bearing it's the only thing that counts

JOT that fact down on the margin of your blue-print now ... file it away in one of the pigeon holes of your mind. Performance is the thing you want when you buy a bearing. Performance, in a bearing, is the only thing that counts.

SKF is a symbol of a world-wide bearing organization that has persistently refused to manufacture down to a price. SKF is the highest priced bearing in the world.

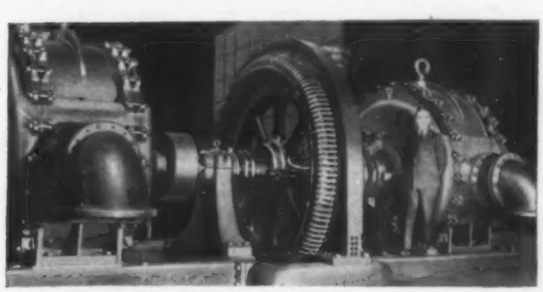
And yet, there flow into SKF Headquarters reports of SKF Bearings that have traveled a million miles in railway journals without showing wear . . . of other SKF Bearings that are part of the mechanical equipment of practically every trans-oceanic flight . . . of others still that serve year after year on thousands of industrial jobs.

Performance ... that's it ... Performance. It's the thing that makes the SKF Bearing more expensive to produce and to buy. It is the thing that makes it cheaper, far cheaper, to use. Put YOUR bearing problems up to SKF. **SKF** Industries, Inc., 40 East 34th Street, New York, N. Y.

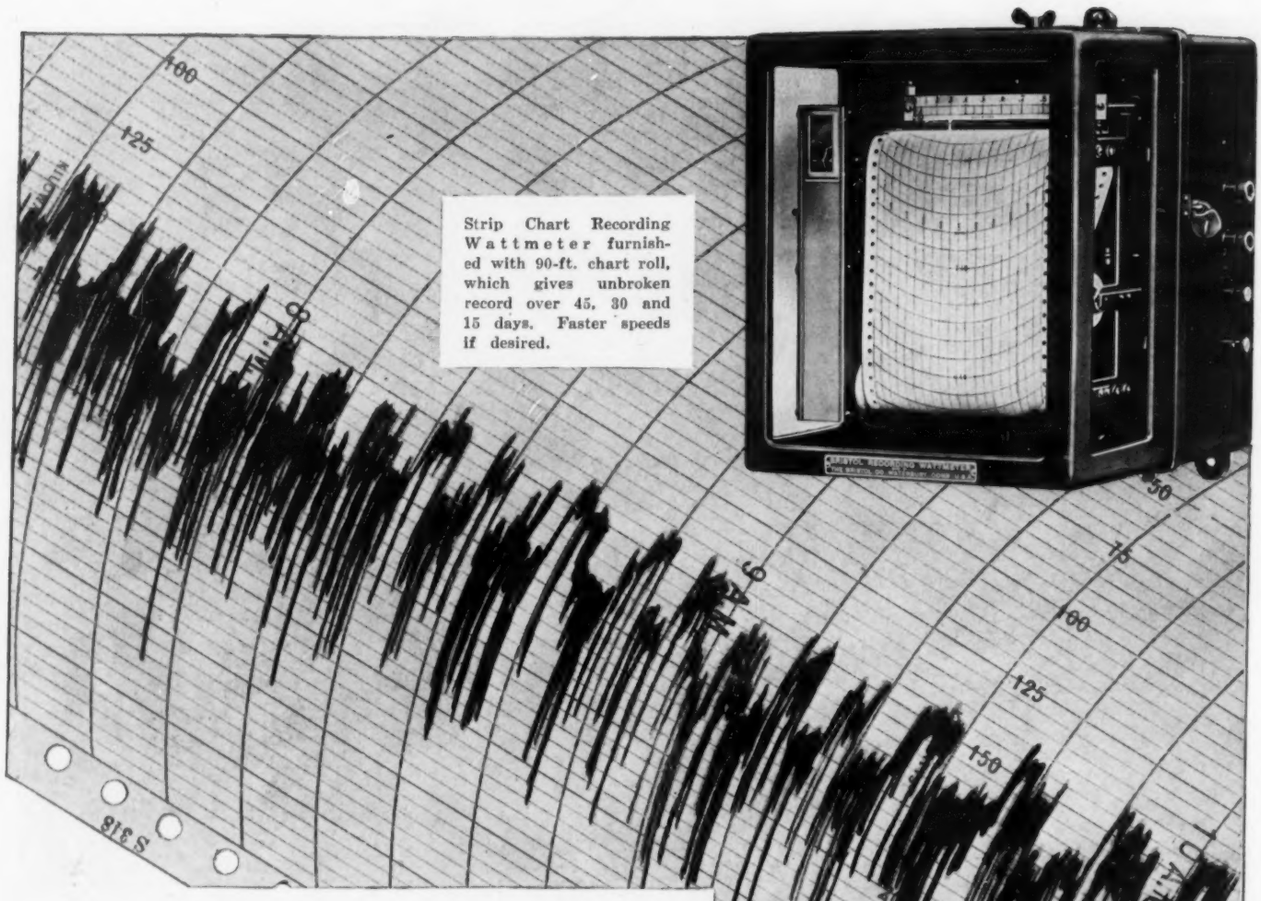
SKF

2587

THE · HIGHEST · PRICED BEARING · IN · THE · WORLD



Performance was the thing that inspired the choice of SKF Bearings for these giant pumps, made by the Nash Engineering Company of South Norwalk, Conn. Photograph illustrates the largest vacuum pump installation in the world.



Strip Chart Recording Wattmeter furnished with 90-ft. chart roll, which gives unbroken record over 45, 30 and 15 days. Faster speeds if desired.

ELECTRICAL LOAD
CONDITIONS AT A GLANCE

The exact **time** and **extent** of all load fluctuations taking place during each day's run is shown in detail on chart records obtained with Bristol's Recording Wattmeters. These instruments are frequently installed on incoming feeder lines to record total incoming load; on department feeder lines to check load distribution; and in the portable form are ideal for making individual motor efficiency tests.

Accuracy and durability can best be attested by the fact that many installations in steel mills, where operating conditions are particularly critical, have piled up continuous service records ranging up to more than 30 years, and in many instances are still on the job 24 hours a day.

Send for Catalog No. 1502. It contains complete information.

The complete Bristol's Electrical Recording Instrument Line includes:

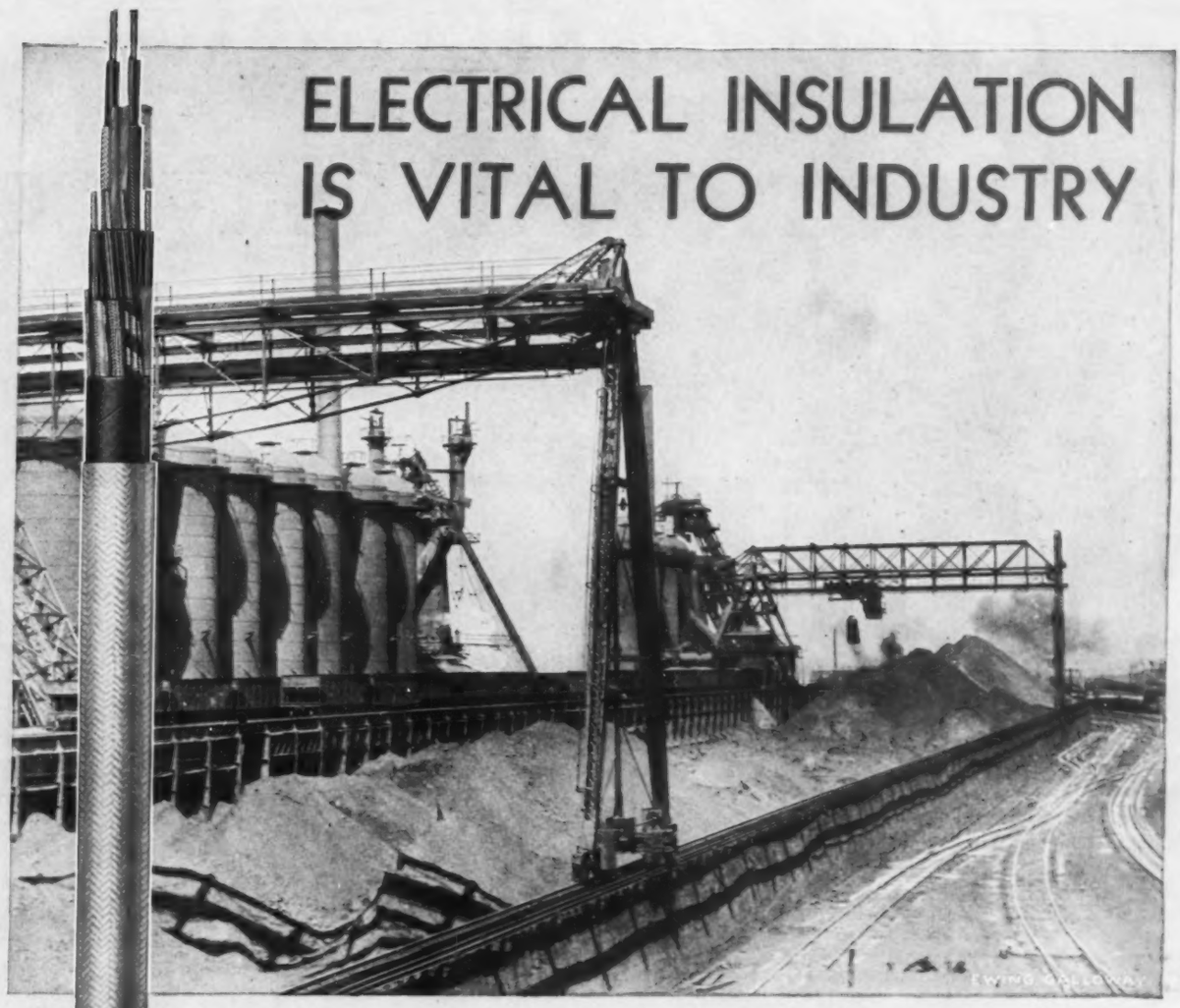
Wattmeters, Ammeters, Milli Ammeters, Shunt Ammeters, Voltmeters, Milli Voltmeters, Frequency Meters. Also Recording Instruments for Pressure, Vacuum, Liquid Level, Temperature, Speed, Motion, etc., and Automatic Control equipment for Temperature, Pressure and Liquid Level, etc.

The Bristol Co., Waterbury, Conn.

Branch Offices:

Boston	Philadelphia	Birmingham	Detroit	Denver	Los Angeles
New York	Pittsburgh	Akron	Chicago	St. Louis	San Francisco

ELECTRICAL INSULATION IS VITAL TO INDUSTRY



Electric Gantry Cranes Handling Ore Into Blast Furnaces at a Large Steel Mill.

OKONITE PRODUCTS

Okonite Insulated Wires and Cables

Varnished Cambric Cables

Okonite Insulating Tape

Manson & Dundee Friction Tapes

Okocord

Okoloom

OKONITE-CALLENDER PRODUCTS

Impregnated Paper Cables

Super-tension Cables

Splicing Materials

MODERN industry with its highly specialized and expensive tools, its vast investments in buildings, equipment and processes, is apt to purchase electric wires and cables after only a casual consideration of their quality.

But modern industry is dependent for power upon electricity. Insulated wires and cables, which direct that power, deserve the most careful thought in their selection.

And so we persistently draw attention to the high quality and dependable service of OKONITE. Admittedly it costs somewhat more *by the foot.* But, after installation, its comparative cost per foot is so little higher and its cost per year of service so much lower that it pays handsomely to use it.

THE OKONITE COMPANY

Founded 1878

THE OKONITE-CALLENDER CABLE COMPANY, INC.

Factories: Passaic, N. J. Paterson, N. J.

SALES OFFICES:

NEW YORK CHICAGO PHILADELPHIA PITTSBURGH ST. LOUIS BOSTON
ATLANTA BIRMINGHAM SAN FRANCISCO LOS ANGELES SEATTLE DALLAS

Novelty Electric Co., Philadelphia, Pa.
F. D. Lawrence Electric Co., Cincinnati, O.

Canadian Representatives:
Engineering Materials, Limited, Montreal

Cuban Representatives:
Victor G. Mendoza Co., Havana

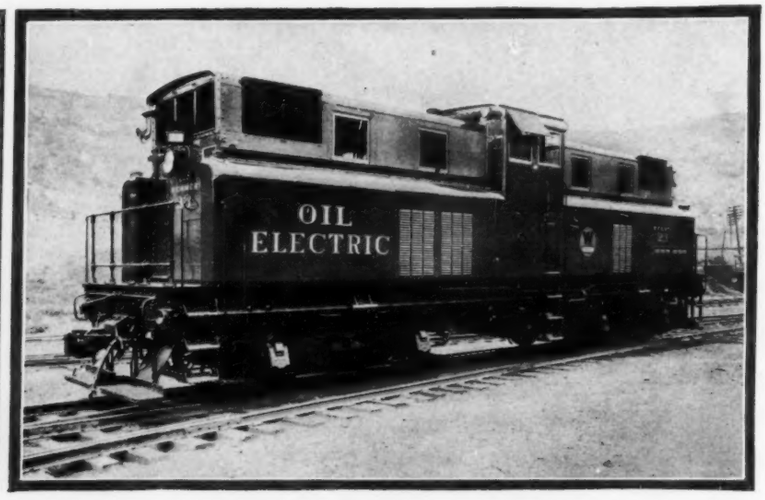
OKONITE QUALITY CANNOT BE WRITTEN INTO A SPECIFICATION

Taking the SHADOW *of* FRACTIONAL SERVICE *off your books*

These operating fractions shadow your books

Under steam operation, the costs of branch line and switching service have virtually eclipsed profits. Fuel consumes too high a fraction of income; time out for overhauling and repairs cuts too large a fraction from availability; maintenance eats up too large a fraction of revenue; these fractions, and others, all cast their shadowy traces on the profit sheets.

Management must cope with them to improve its operating fraction.



TODAY, more than ever before, industry demands complete service of all its tools. The Oil Electric supplies this service in the line of rail transportation.

The latest Westinghouse unit will effect a major reduction in your shadows of fractional service, —in actual operating time, standby time, and maintenance.

With more uniform starting tractive effort and greater ease of control, the Oil Electric performs 10 to 20 per cent more work than the steam locomotive of comparable weight.

The Oil Electric will operate continuously hundreds of hours requiring only ½ to 1 hour out of every 24 for inspection, minor adjustments, and for taking sand and fuel. This assures a gain in availability of 20 per cent over steam operation.

In industrial yards, steam must be maintained over long standby periods. The short starting cycle of the Oil Electric permits complete shutdown during these times.

Service, prompt and efficient, by a coast-to-coast chain of well-equipped shops

Westinghouse

T 31143

TUNE IN THE WESTINGHOUSE SALUTE OVER THE N. B. C. NATION-WIDE NETWORK EVERY TUESDAY EVENING.

Strayer Electric

O-K!

ERIE *Industrial*

This stamp of approval comes from one of the largest Stcel Corporations in the world, after having used a Strayer Electic Bucket in continous service for over a year. It means something when it comes from these fellows. They know buckets—have many of them in use and in real tough service too. So when they say "O-K" you know that this bucket has passed a real test.

HERE ARE A FEW FEATURES OF THIS BUCKET:

It is electrically operated and controlled, and is equipped for Alternating or Direct Current. Only two wires are required for DC; four wires for AC.

It will dig capacity loads of any bulk material such as limestone, iron ore, Fluor-spar, Dolomite, clay, coke, coal, cinder, sand, etc.

It is attached or detached in a minute, and works within its own height.

The operator has complete control of the bucket at all times. As much or as little material can be dug as desired, and in emptying, the bucket can be opened wide or only a few inches at a time.

Few parts, therefore less maintenance. No frictions, clutches, chains, springs or unnecessary parts.

If you have quantities of bulk material to move it can be handled more successfully and economically with the Strayer Electric Bucket. Our Engineers are willing to assist in a survey of your plant to see if the Strayer Electric Bucket will cut your cost of material handling.

Write for this free service.

Clamshell and Electric Buckets

Hook-On Buckets

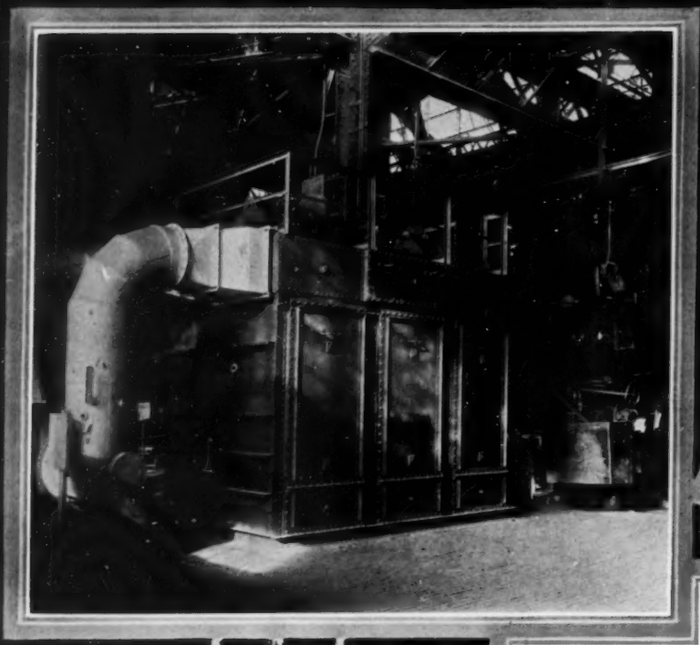
Overhead Electric Traveling Cranes

Digging Foundry Waste is easy with a Strayer Electric Bucket.

ERIE STEEL CONSTRUCTION COMPANY

ERIE, PENNA.

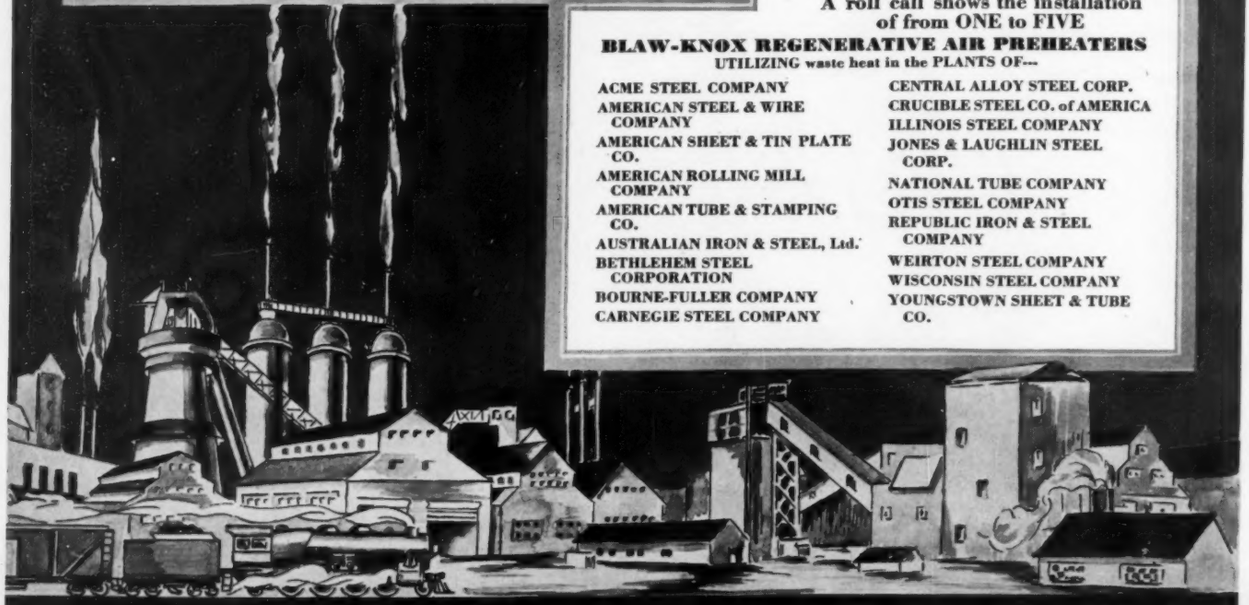
A BIG MAJORITY of the LEADING STEEL COMPANIES in AMERICA use BLAW-KNOX PREHEATERS



BLAW-KNOX
REGENERATIVE AIR PREHEATERS
are the most reliable means for heating air to high temperatures for
BILLET HEATING FURNACES
SLAB HEATING FURNACES
OPEN HEARTH FURNACES
BLAST FURNACE GAS-FIRED BOILERS
SOAKING PITS
Your selection of an AIR PREHEATER might well be guided by the experience of NINETEEN of America's leading manufacturers of steel.
Blaw-Knox Company
2094 Farmers Bank Bldg.
Pittsburgh, Pa.
Offices and Representatives in all Principal Cities

A roll call shows the installation of from ONE to FIVE
BLAW-KNOX REGENERATIVE AIR PREHEATERS
UTILIZING waste heat in the PLANTS OF—

ACME STEEL COMPANY
AMERICAN STEEL & WIRE COMPANY
AMERICAN SHEET & TIN PLATE CO.
AMERICAN ROLLING MILL COMPANY
AMERICAN TUBE & STAMPING CO.
AUSTRALIAN IRON & STEEL, Ltd.
BETHLEHEM STEEL CORPORATION
BOURNE-FULLER COMPANY
CARNEGIE STEEL COMPANY
CENTRAL ALLOY STEEL CORP.
CRUCIBLE STEEL CO. of AMERICA
ILLINOIS STEEL COMPANY
JONES & LAUGHLIN STEEL CORP.
NATIONAL TUBE COMPANY
OTIS STEEL COMPANY
REPUBLIC IRON & STEEL COMPANY
WEIRTON STEEL COMPANY
WISCONSIN STEEL COMPANY
YOUNGSTOWN SHEET & TUBE CO.



BLAW-KNOX

WHY ARE THEY CALLED "TOOL STEEL" GEARS?

Occasionally someone who does not read carefully the description of "Tool Steel" gears, crane wheels, and other products contained in our literature, gets the impression that they are made from a solid homogeneous high carbon tool steel. We have never tried in any way to convey such an impression. Our products are made from a low carbon steel, either plain or alloy to suit conditions, and the wearing surfaces are then carburized and hardened by our own special process to such depth as may be required by operating conditions.

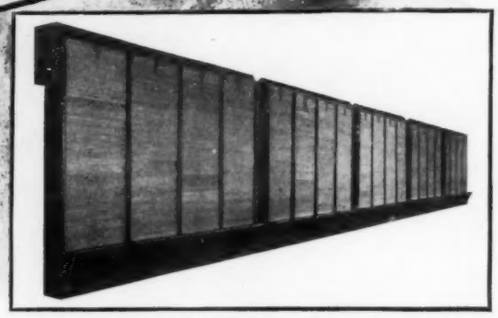
The name "Tool Steel" was selected as a descriptive or trade name for our product because the outside wearing surface is converted by our carburizing process from a low carbon to a high carbon steel having the hardness and high carbon content of a good tool steel.

This high carbon hardened case or wearing surface, testing from 85 to 95 by the scleroscope, penetrates to approximately the depth or limit of permissible wear and gives the long life of "Tool Steel" gears and other products. The soft, low carbon steel core or center of our material, refined by heating treatment, gives the necessary strength and ductility supporting the hardened surface.

THE TOOL STEEL GEAR & PINION CO.,

CINCINNATI, OHIO

DUST



Five American Multi-Panel Air Filters of type used by the plant referred to in this advertisement

WROTE $10,000 CHECKS AT YOUNGSTOWN

The rating of a frequency changer in a Sub Station of a large steel company in the Youngstown district* is 9,375 Kva. During the summer months, the maximum continuous load with natural ventilation was 7,500 Kva. Forced ventilation was applied in April 1930. American Multi-Panel Air Filters were installed to remove dust and soot from the cooling air. Since that time the maximum safe load has been increased approximately 1,000 Kva. The increased rating of the frequency changer is equivalent to a saving of $10,368 on extra power generated by the improved equipment during the six months when cooling is necessary.

Without air filters to remove dust from the cooling air, forced ventilation would have been impossible. Dust was therefore writing its own check for over $10,000 a year on this one installation.

Protect your electrical equipment from overheating and short circuits due to dust. Increase its capacity. Prolong its life. Write today for information. AMERICAN AIR FILTER COMPANY, *Incorporated*, General Offices, 130 Central Avenue, Louisville, Ky. Factories, Louisville, Ky., and Bradford, Pa.

* Name on request.

AMERICAN AIR FILTERS

MIDWEST TRADE MARK

Reed Air TRADE MARK filters ALL METAL

NATIONAL AIR FILTERS TRADE MARK

10 CRANES equipped like this!

Clark "3C" Vari-Time Magnetic Controllers for Cranes

Proof by trial is conclusive.

Repeat orders duplicating the above illustrated installation give indisputable evidence of the merits of Clark Crane Control equipment. Hoist, Bridge and Trolley all controlled by Clark.

Write for Bulletin 114.

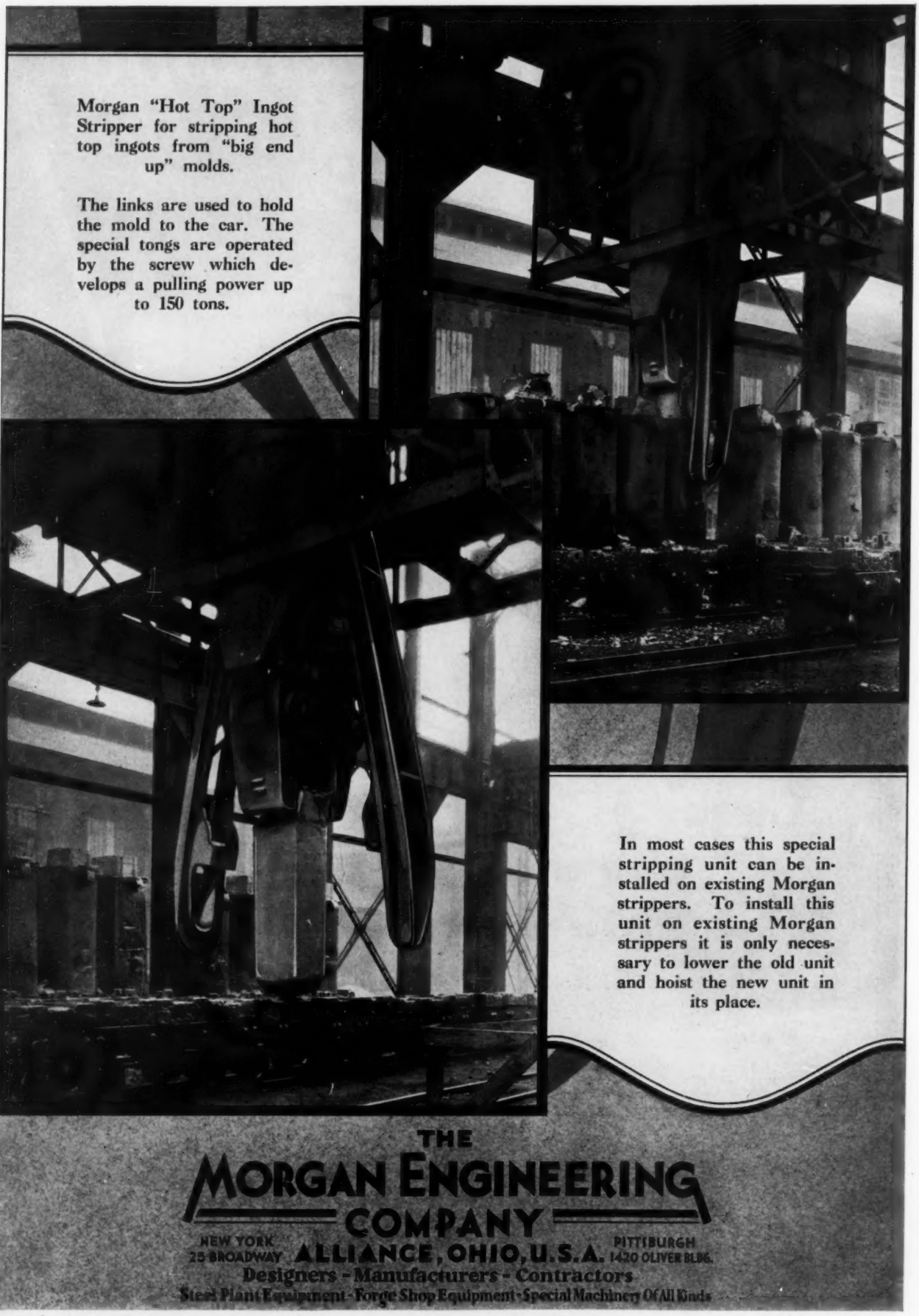
THE CLARK CONTROLLER CO.

• PHILADELPHIA • CANTON, O. • CHICAGO • DETROIT • PITTSBURGH •

AGENCIES IN U. S. A.
BIRMINGHAM CINCINNATI
KANSAS CITY ST. LOUIS

CLEVELAND, O.

AGENCY IN CANADA
RAILWAY & POWER ENGINEERING CORPORATION, LIMITED



Morgan "Hot Top" Ingot Stripper for stripping hot top ingots from "big end up" molds.

The links are used to hold the mold to the car. The special tongs are operated by the screw which develops a pulling power up to 150 tons.

In most cases this special stripping unit can be installed on existing Morgan strippers. To install this unit on existing Morgan strippers it is only necessary to lower the old unit and hoist the new unit in its place.

THE
MORGAN ENGINEERING
COMPANY

NEW YORK
25 BROADWAY

ALLIANCE, OHIO, U.S.A.

PITTSBURGH
1420 OLIVER BLDG.

Designers - Manufacturers - Contractors

Steel Plant Equipment - Forge Shop Equipment - Special Machinery Of All Kinds

Surface Combustion

A STEP AHEAD of INDUSTRY'S NEEDS!

Surface Combustion—through constant research and development—keeps a step ahead of trends in the sheet industry. Changes in requirements—changes in methods—all are recognized and anticipated in furnaces of advanced design. That's why the nation's largest sheet mills depend on Surface Combustion to build furnaces for their specific needs.

Consult with S. C. engineers for a modern and economical solution of your problems.

The Surface Combustion Co.
INCORPORATED
Subsidiary of Henry L. Doherty & Co.
2375 DORR STREET, TOLEDO, OHIO
Branch Offices in All Principal Cities
Mantle Recuperator Division — Webster Engineering Co.
Member of Industrial Furnace Manufacturers Association

This battery of eight SC walking beam furnaces, installed in a large sheet mill, operates with efficiency and economy on both pair and pack heating. Again SC over and under firing with two-stage velocity burners, and full automatic temperature control, demonstrates its value for quality sheet production.

Combustion

DELAYED ACTION COOLS

the Arcing Chambers Before Opened to Atmosphere

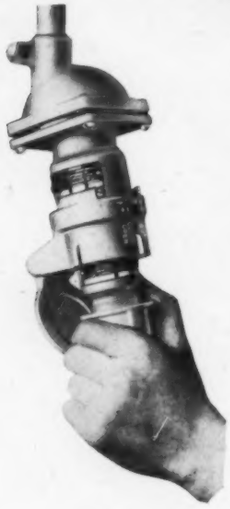


Fig. 1
Circuit Closed
Plug about to be Withdrawn

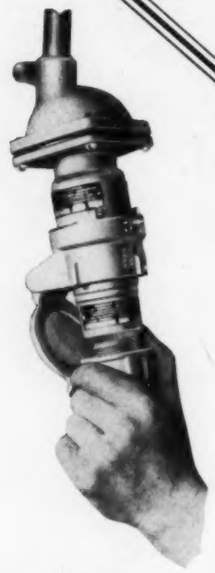


Fig. 2
Circuit Broken
Plug Partially Withdrawn
(Interlocking Sleeve Prevents Plug from being further Withdrawn)

Fig. 3
Interlocking Sleeve Revolved
Plug can now be Withdrawn

Fig. 4
Plug Completely Withdrawn

ARKTITE plugs and receptacles with interlocking sleeve have a greater degree of safety, for use in hazardous locations, than the ordinary explosion-proof switch.

The interlocking sleeve produces a delayed action which will permit the arc to be broken in the arcing chamber and the resulting flame to cool below the ignition temperature before the arcing chamber is opened to the atmosphere.

These plugs and receptacles are provided with an extra pole so that the copper grounding conductor is connected not only from the portable device to the plug, but also from the receptacle to the ground.

(Listed in Bulletin 2217)

CROUSE-HINDS

ESTABLISHED 1897

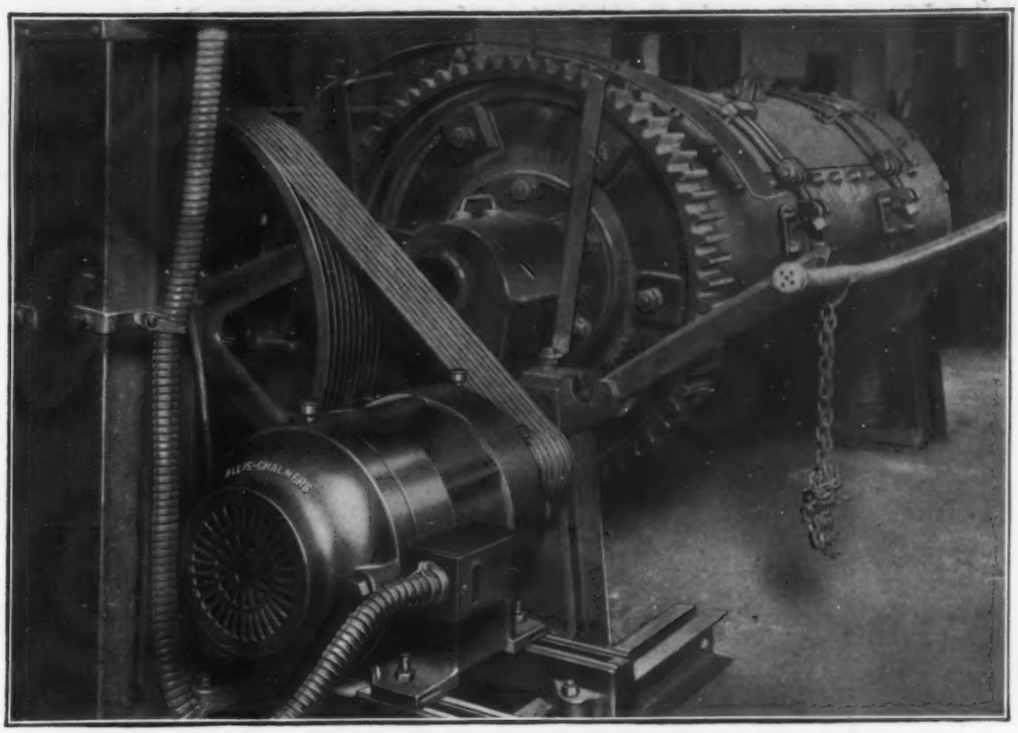
SYRACUSE, N. Y., U. S. A.

CANADIAN PLANT: TORONTO, ONTARIO

SALES OFFICES

BOSTON NEW YORK DETROIT PHILADELPHIA ATLANTA MILWAUKEE CHICAGO ST. LOUIS CLEVELAND CINCINNATI MINNEAPOLIS PITTSBURGH LOS ANGELES SAN FRANCISCO DALLAS SEATTLE

C-H 554



ARZ motor and Texrope drive operating tumbling mill in an iron foundry cleaning small castings.

Even Iron Dust is Harmless

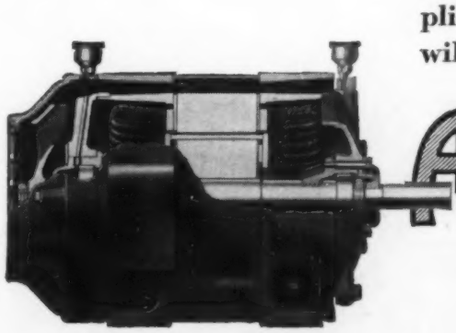
to these enclosed fan-cooled motors

Even in an atmosphere laden with iron dust and fine sand this Allis-Chalmers totally enclosed fan-cooled motor operates without trouble as the dust and dirt cannot get inside the motor.

Previously an open type motor was used for driving the tumbling barrel and required frequent repairing due to the iron dust working through the insulation, causing burnouts.

Allis-Chalmers totally enclosed fan-cooled motors are permanently protected against the effects of dust, dirt, moisture, or similar destructive agents. The unique means by which this protection is accomplished is described in Leaflet 2124, a copy of which will be sent you on request.

This motor is ideally suited for locations where dust, dirt, acid fumes or moisture tend to shorten the life of motor windings. It is particularly applicable to carbon black plants, foundries, cement plants, textile mills, chemical plants, coal preparation or for outdoor service, etc.



ALLIS-CHALMERS

Totally Enclosed Fan-cooled MOTORS

Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin

Eliminate Risks

ROLL NECK PRESSURES need no longer be an unknown and therefore dangerous factor in the application of roller bearings to roll necks since they can be determined by

ROLLWAY'S
Electric Telemeter Oscillograph Apparatus

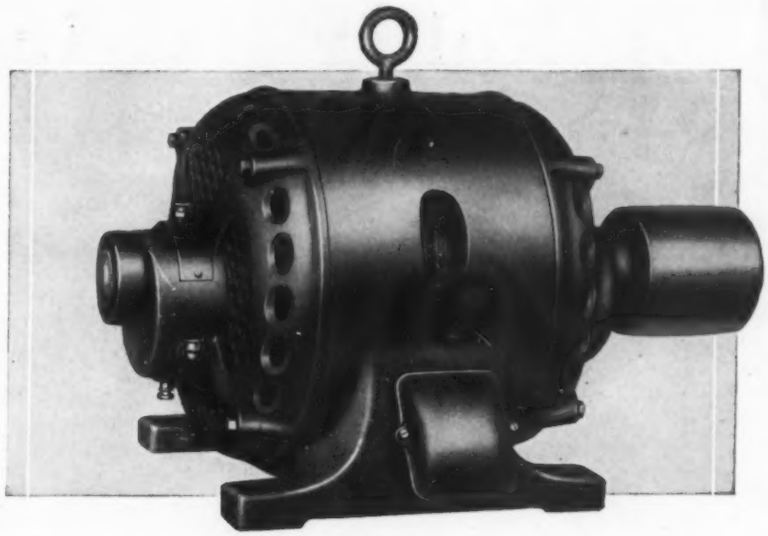
This new method, described in the November, 1930, issue of the Iron & Steel Engineer, measures pressures accurately, instantaneously and without interference to mill production or gauge of material being rolled. It eliminates risk, by making possible the design and application of the proper size roller bearings, suitable for each job.

Submit your bearing problems to us. We shall be glad to make tests in your mills without obligation. Write us for more detail information.

ROLLWAY BEARING
COMPANY INCORPORATED
SYRACUSE NEW YORK

ROLLWAY
CYLINDRICAL ROLLER
BEARINGS

THEY KEEP A-RUNNING



10 Horse Power Century Type SCN Squirrel Cage Induction 3 and 2 Phase 60 Cycle Motor.

GENERAL PURPOSE APPLICATION

LOW STARTING CURRENT
NORMAL TORQUE

Because no current-limiting starting equipment is necessary in 30 horse power and smaller Century Type SCN Squirrel Cage Motors, they may be controlled by any standard approved starting switch or starter. This means greater economy in installation and maintenance. In addition, full advantage is taken of the current drawn from the line since no current is absorbed in starting equipment.

The starting torque of these motors is practically the same as that of the standard type SC Squirrel Cage Motor. This makes them particularly suitable for all general purpose applications where normal starting torque is satisfactory and where the omission of current-limiting starting equipment is permissible.

Century polyphase motors are built in standard sizes from ¼ to 250 Horse Power.

CENTURY ELECTRIC COMPANY
1806 PINE STREET • • ST. LOUIS, MO.
40 U. S. and Canadian Stock Points and More Than 75 Outside Thereof

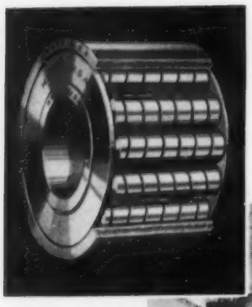
809

SINGLE PHASE, THREE PHASE, AND DIRECT CURRENT MOTORS

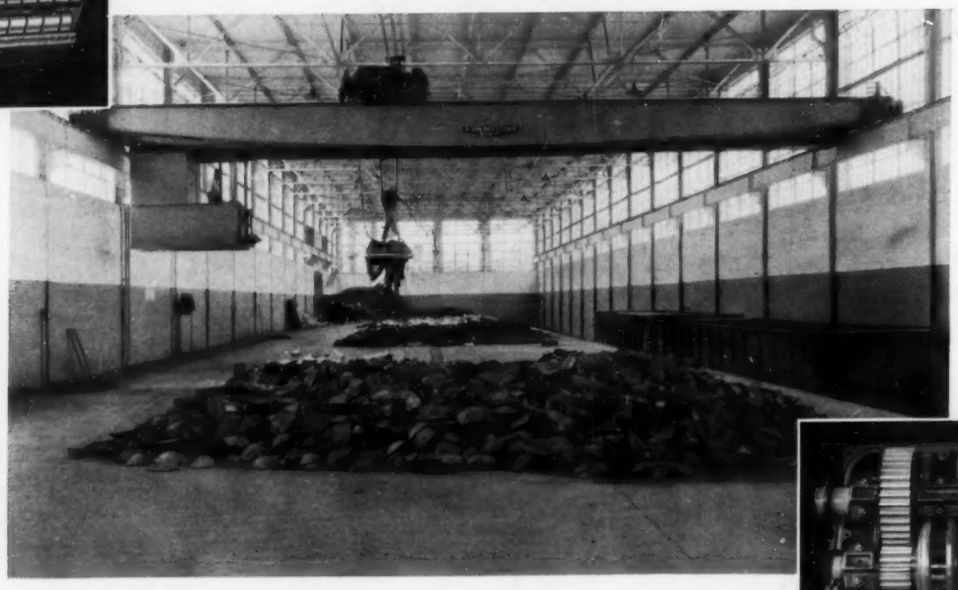
Century MOTORS

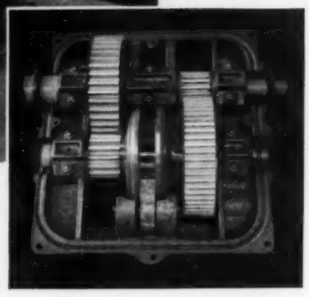
MOTOR GENERATOR SETS, ROTARY CONVERTORS, FANS AND VENTILATORS

FOR MORE THAN 26 YEARS AT ST. LOUIS



COMPACT STRENGTH on Roller Bearings





for unyielding rigidity

High speed reduction gears, load-brake and bearings are compacted into a unit housing in the Niles Crane Trolley. Alignment is lasting — support rigid. And lubrication for all moving parts is positive and continuous from an oil bath within the housing.

Added protection, to insure low cost load handling is provided by roller bearings at every rotating support. Friction is practically banished. Wear is minimized and alignment made permanent.

When you need an electric traveling crane—from 5 to 450 tons capacity — choose a Niles. It's doubly fortified to assure last efficiency.

SHEPARD NILES CRANE & HOIST CORPORATION

376 Schuyler Ave., Montour Falls, N. Y.

Branches in Principal Cities. Works: Montour Falls, N. Y.; Philadelphia, Pa.

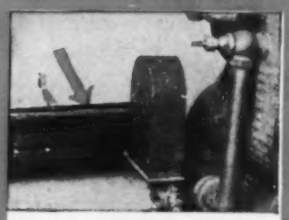
Member EHMA ELECTRIC HOIST MANUFACTURERS ASSOCIATION

NILES CRANE DIVISION

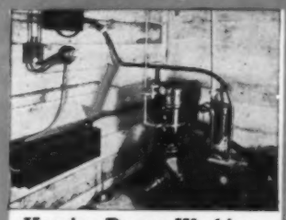
THE MOST COMPLETE LINE OF CRANES AND HOISTS IN AMERICA

The Answer to your cold weather heating jobs...

In Crane Cabs



Protecting Sprinkler Valves



Keeping Pumps Working

In Sub-stations

In Isolated Offices, Shops

Write for your copy—
No obligation

ELECTRIC AIR HEATERS

Easily and Quickly Installed Anywhere! 45 Sizes and Ratings. Three Types—Horizontal, Vertical, and Portable. 1000, 1500, 2000, 3000 watts. 110, 220, 250, 440, 550 volts. Completely assembled with 3-ft. armored cable and 3-heat switch; or Automatic Control, extra. Always ready. End complaints about "there isn't any heat." 20% more heat. All heat is utilized for air heating! NO FIRE HAZARD. Temperature between heater case and wall kept far below fire hazard point. Built to last. Hundreds in use. Same type heaters used on 230 railways. Use coupon below.

STRIP AND SPACE HEATERS

80 sizes of Strip Heaters, 8″ to 72″ long. For all kinds of heating jobs. Heating ovens and tanks; keeping pipe lines from freezing; melting anything from metal to grease; heating machines, equipment, special processes; preheating fuel oil. Also used as resistance to take up induction kicks. Hundreds of companies are saving time and money on their heating jobs by switching over to Chromalox heaters. Whether yours is a big job or a small one . . . low temperature or one that runs up to 1100 degrees F., tell us about it when you send for your copy of C-108-A. No obligation!

**Tear Off and Mail with Your Letterhead*

Memo to Edwin L. Wiegand Company, 7545 Thomas Blvd., Pittsburgh, Pa.

Yes, we need more heat around here. Without obligation, send Bulletin C-108-A and please tell us right away how to properly heat a space used for:

I&SE 12-30

.....

which is.....ft. long.....ft. wide.....ft. high

having.....windows.....doors

Signed.....Position.....

Company.....Address.....

GENERAL DEVICES & FITTINGS CO.

LET US QUOTE ON YOUR REQUIREMENTS

GENERAL DEVICES AND FITTINGS CO.

J. H. Albrecht, Steel Mill Representative United States and Canada

614 EMPIRE BUILDING, PITTSBURGH, PA.

Other Products; Bus Bar Supports, Crane Rail Supports, Pipe Frame Fittings, Bus Clamps, Copper Terminal and Fittings, Gang Operated Disconnecting Switches

Friend

"Bill Maintenance" has two sides to him — two characters. He is either a helpful fellow worker doing a good job day after day — or he's an unknown menace.

or Enemy?

You can't get rid of "Bill Maintenance"; you can never fire him from the payroll. What you've got to do is to watch him — and treat him right.

"Bill Maintenance"

What is he doing in your plant?

IT'S up to *you* which part he plays.—Is he keeping your equipment in perfect running order, day after day? Or is he—unknown to you — constantly "smashing" into your profits?

If some valuable machinery of yours were wrecked by a sledge hammer, the expense and time involved in repairs would not compare with the constant wear, the continual increasing maintenance costs resulting in the year by year use of lubricants *not made for the job.*

Put it up to us to keep "Bill Maintenance" in his proper place. We have done it for industry after industry. Not only through the quality of all Keystone Greases—with their unchanging density and their honest body—*but above all because of our knowledge of the correct application of the correct density of Keystone Grease for every job.*

Your equipment will accomplish more work and harder work *at an actual annual saving.* Repair bills will be cut to the minimum, your lubricant costs will be definitely reduced.—We will gladly send a Keystone Engineer to talk it over with you. Keystone Lubricating Company, 21st, Clearfield & Lippincott Sts., Phila., Pa. Est. 1884.

KEYSTONE *Lubricants*

KEYSTONE GREASE

© 1930 Keystone Lubricating Co.

Completely ELECTRIFIED!

The World's Largest Wrought Iron Pipe Plant

The new A. M. Byers Plant at Economy, Pa., the largest and most modernly equipped plant of its kind in the country, is designed to utilize Central Station Power Service throughout.

Each step in the manufacture of wrought iron pipe, by the famous new Aston Process is carried on electrically. The A. M. Byers Company, in striving to effect every possible economy in manufacture, recognized a reliable ally in the extensive application of Electric Power. Purchased power is an economy, and particularly when it is available at rates among the lowest in the country.

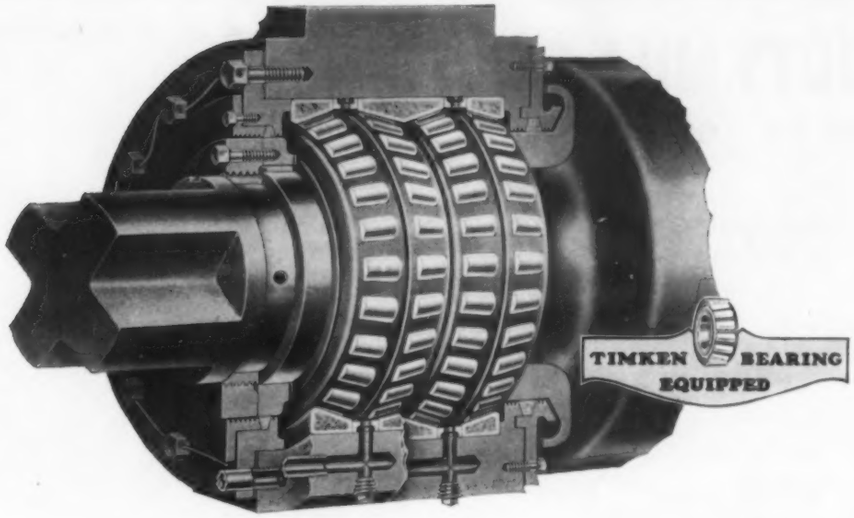
Duquesne Light Company Engineers are ready to assist in the planning of power requirements for any new or revised manufacturing plants.

Call Grant 4300 - - Line 233

DUQUESNE LIGHT COMPANY

The New James H. Reed Power Station, recently completed, is additional assurance of reliable and plentiful Power Service for the years to come.

BYLLESBY ENGINEERING MANAGEMENT PIONEERS IN PUBLIC SERVICE



More than 425,000 Tons of Steel on Timken Bearings

Installed in the plant of a large steel company, is a mill that has been operated on Timken Bearings ever since it was placed in service over 3 years ago.

During this time, 425,000 tons of steel have been rolled on it—an impressive total that tells its own story of Timken dependability in this punishing service.

The Timken Bearings are of 12½" bore x 25½" O.D., capacity 1,715,000 lbs.

Where is the plain-bearing mill capable of even approaching this accomplishment without frequent involuntary stoppages and costly bearing replacements?

The steady forward sweep of Timken Bearings in the steel industry forecasts the end of the day of the plain roll-neck bearing.

Plain-bearing rolling mills are rapidly reaching the obsolescent stage, and progressive steel operators are turning to Timken for modern roll-neck bearing performance as demonstrated by such accomplishments as that described above.

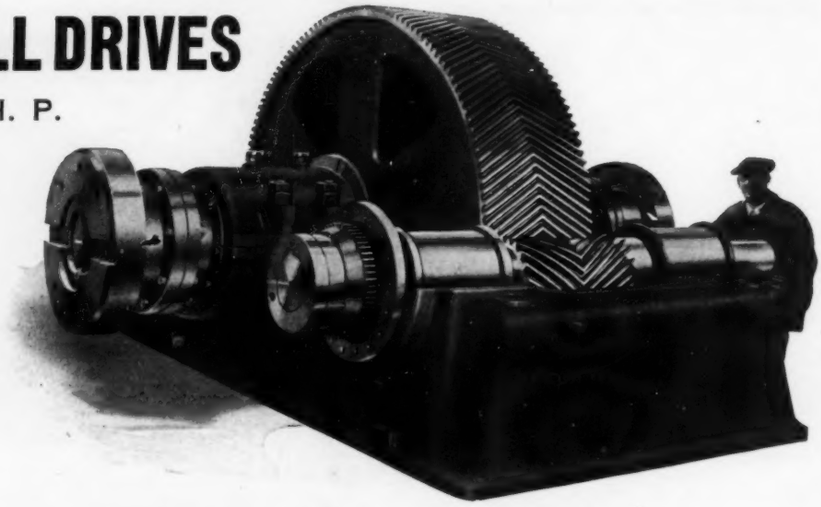
And when proved power savings of from 40 to 50% are added to this supreme endurance, it would seem to be sound policy to consider discarding obsolescent rolling mill equipment and obtaining immediately the production and profit-protecting advantages of Timken tapered construction, Timken positively aligned rolls and Timken-made steel.

THE TIMKEN ROLLER BEARING CO., CANTON, OHIO

TIMKEN *Tapered Roller* **BEARINGS**

HEAVY DUTY MILL DRIVES

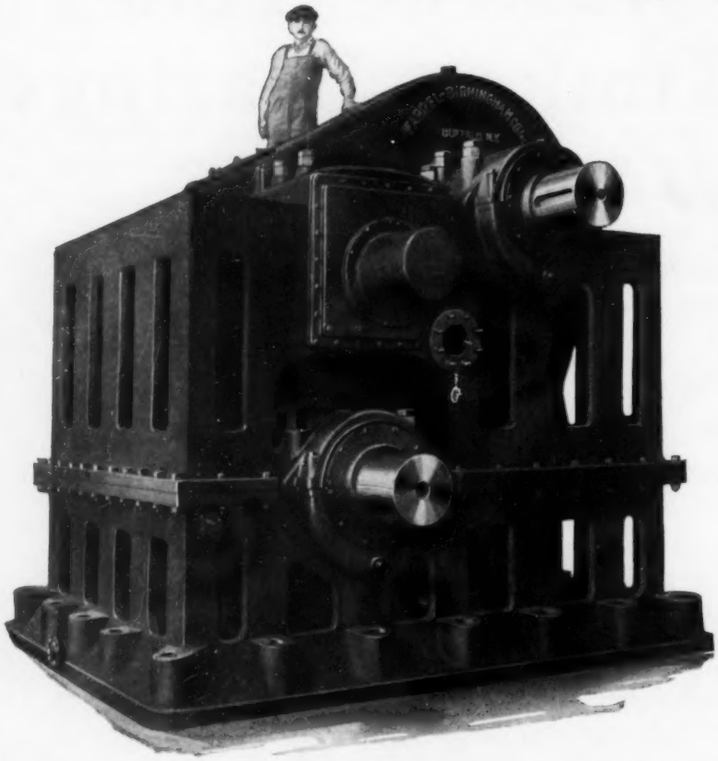
UP TO 10000 H. P.

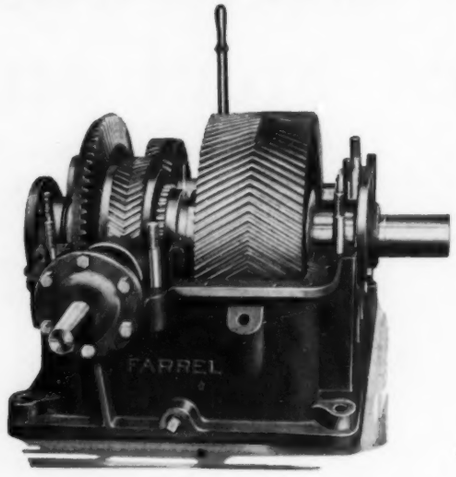


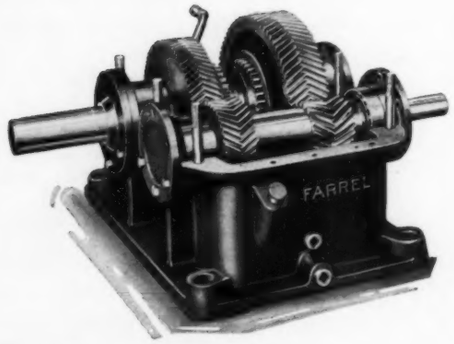
Farrel-Sykes Herringbone gears up to 4½ C. P. 20 ft. dia.

Mill Pinions up to 4½ C. P. 54" Face in Carbon Steel or Alloy Steel Heat Treated and Tempered.

UNITS OF SPECIAL DESIGN







When local conditions necessitate units of special design it is generally profitable to submit the problem to our engineering department. Not only is a specialist knowledge desirable but we may have already solved the problem and have drawings and patterns which will, of course, reduce the initial cost.

FARREL-BIRMINGHAM CO. Inc.

SUCCESSOR TO
FARREL FOUNDRY & MACHINE CO., ANSONIA, CONN., AND
BUFFALO, N.Y., AND BIRMINGHAM IRON FOUNDRY OF DERBY, CONN.
ADDRESS REPLIES TO THIS ADVERTISEMENT TO BUFFALO PLANT
344 VULCAN ST., BUFFALO, N.Y.

Should a Control Wire Ground!

Standardized Control Helps the Trouble Shooter

200 Ton Morgan Ladle Crane
equipped with EC&M Control

WHEN you have standardized control on every crane, it is a real aid to the trouble shooter—the maintenance electrician. Not only is he familiar with every part, thereby enabling him to give accurate periodical inspection, but in emergencies, he can quickly remedy any difficulties that unexpectedly arise, because he is master of the circuits.

This means, that no matter where the difficulty may lie—a broken collector shoe or a grounded control wire —a minimum of time is lost. This is particularly important in steel mill service. As illustrated above, for example, a prolonged delay on this 200 Ton Morgan Ladle Crane with the ladle full of molten metal would prove very serious.

This is only one of the many reasons why this plant employs EC&M Control on its cranes. Other outstanding reasons are — a minimum spare part problem — the ability of one operator to fill in for an absent one when an important task must be completed and the interchanging of operators which enables you to select the smoothest working combination of crane and operator.

Specify EC&M Control for your Cranes

THE ELECTRIC CONTROLLER & MFG. CO.

CLEVELAND, OHIO

NEW YORK-50 CHURCH ST.
CHICAGO-CONWAY BLDG.
DETROIT-DIME BANK BLDG.
BIRMINGHAM-BROWN-MARX BLDG.
CINCINNATI-1ST NATIONAL BANK BLDG.
ST. LOUIS-6935 MARQUETTE AVE.
LOS ANGELES-912 E. THIRD ST.
HOUSTON-P.O. BOX 4182
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PITTSBURGH-OLIVER BLDG.
SAN FRANCISCO-CALL BUILDING
MONTREAL-CASTLE BLDG.
TULSA-217 E. ARCHER ST.
SEATTLE-ALASKA BLDG.

STEEL *for* STRENGTH

Type AA Reliance Squirrel-cage Induction Motor with ball bearings.

The outlet for conduit connections can be turned at any angle. It is made in two halves which are removed when making connections.

Stator frames like this are used for all sizes of Reliance Induction Motors. The frame is made of bar steel, electrically welded. This construction provides extra strength and rigidity.

Engineers in the steel and tube mills are constantly emphasizing the importance of ruggedness in general-purpose motors. For Reliance Induction Motors therefore we have adopted even for the small sizes the same substantial frame construction as used in building large motors for heavy-duty service.

The frame is fabricated entirely from bar steel electrically welded. This provides a strong and rigid enclosure for the stator core. The core laminations are also welded to the cross braces of the frame.

With this substantial steel-frame construction as a basis, supplemented by dependable insulation and rotor construction these rugged motors can be relied upon to tackle the hard jobs of steel making with a good record for steady running.

Reliance Electric & Engineering Co.

1080 Ivanhoe Road Cleveland, Ohio

Branches: Birmingham, Boston, Buffalo, Chicago, Cincinnati, Detroit, Los Angeles, New York, Milwaukee, Philadelphia, Pittsburgh, St. Louis, Toledo

Representatives: Denver, Mountain States Machinery Co.; Kansas City, Mo., Chas. L. Ward Co.; Knoxville, A. L. Pollard; San Francisco, Seattle, H. B. Squires Co.

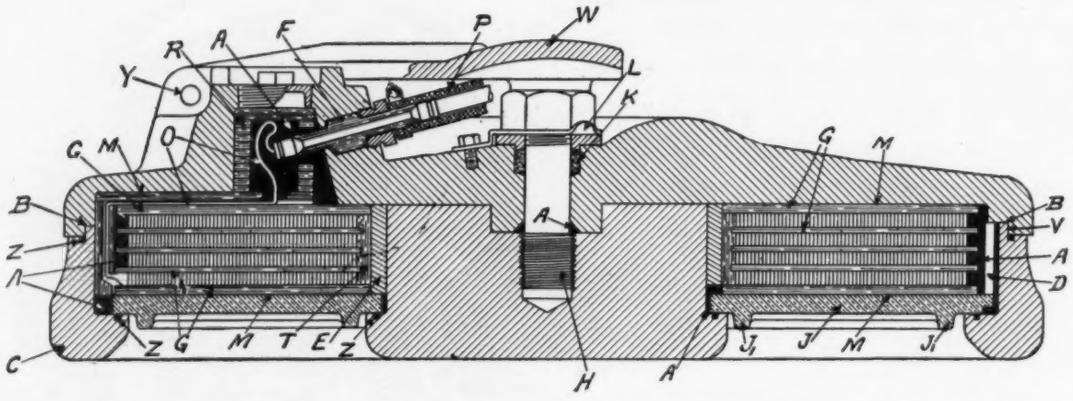
for STEEL-MILL JOBS

Four coats of insulating varnish are baked onto the windings of this Reliance stator. This heavy coating provides extra mechanical protection plus high insulating value. The windings and slots are thoroughly sealed. The result is a longer life where motors are exposed to scale, oil and moisture.

Rotors for Reliance Motors are made with a determination to construct this vital part so well that it will stand any abuse and eliminate all former difficulties. The Reliance welding process definitely ends any worries about rotor connections. Bars and copper end ring are welded into one solid mass. There is no chance of a loose connection from any cause.

RELIANCE A-C D-C MOTORS
with Ball Bearings

Two good reasons for Ohio Magnet Reliability



"J" **Manganese steel bottom plate is ribbed (see J1) to keep the center pole and outer ring from wearing down so far as to allow bottom plate to sag and moisture enter.**

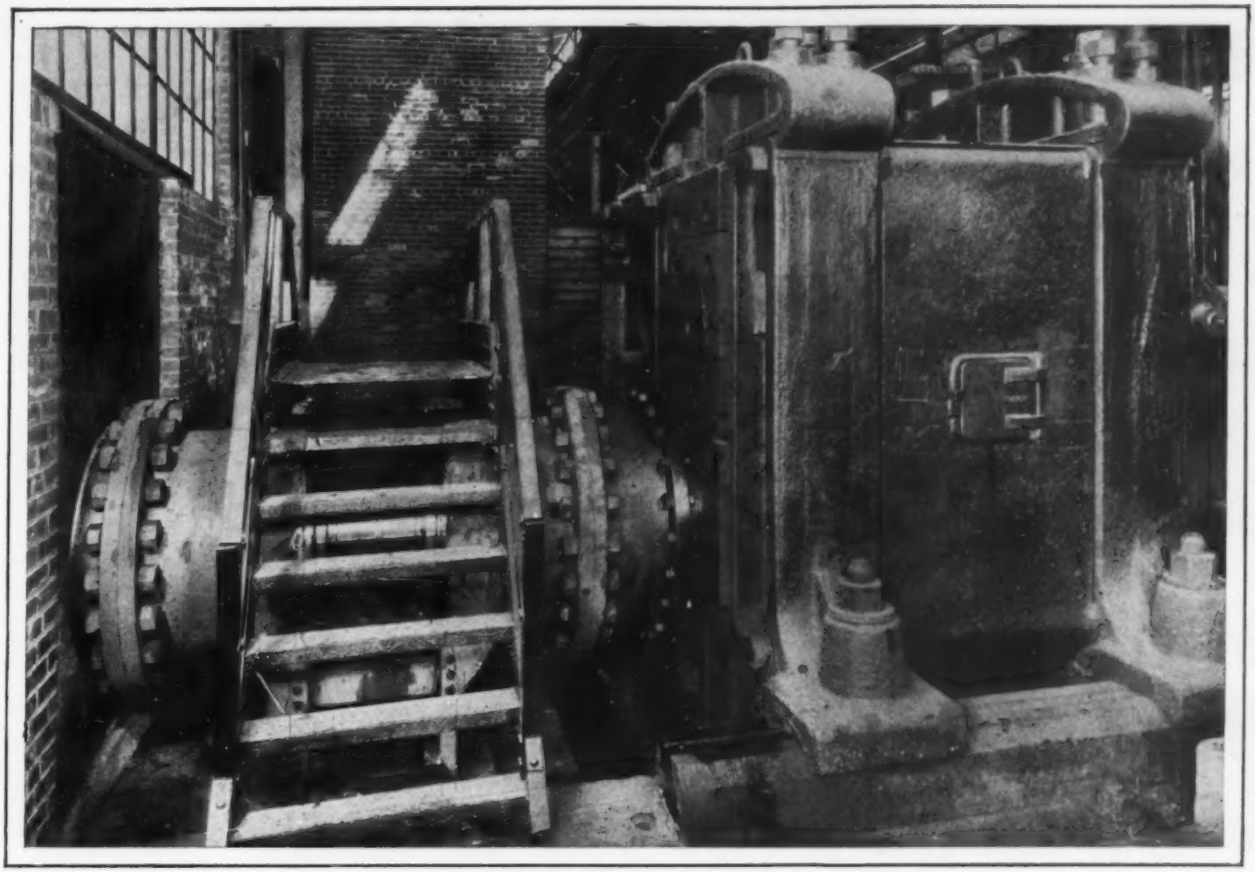
"Y" **Terminal shield "W" is of heavy cast steel and the hinge pin "Y" is riveted so the shield cannot get lost and it must be kept in its proper place else it would hang out over the edge of the magnet and be in the way. Thus the terminal and leads are always protected from dirt or oil.**

OHIO reliable MAGNETS

The Ohio Electric Mfg. Co.

5907 Maurice Avenue

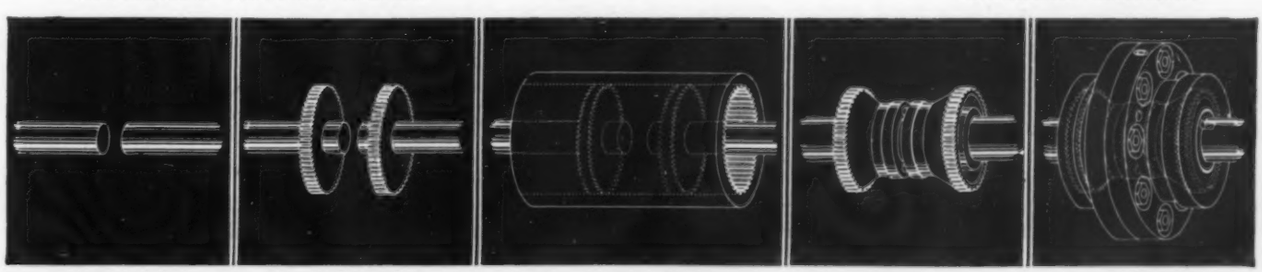
Cleveland, Ohio

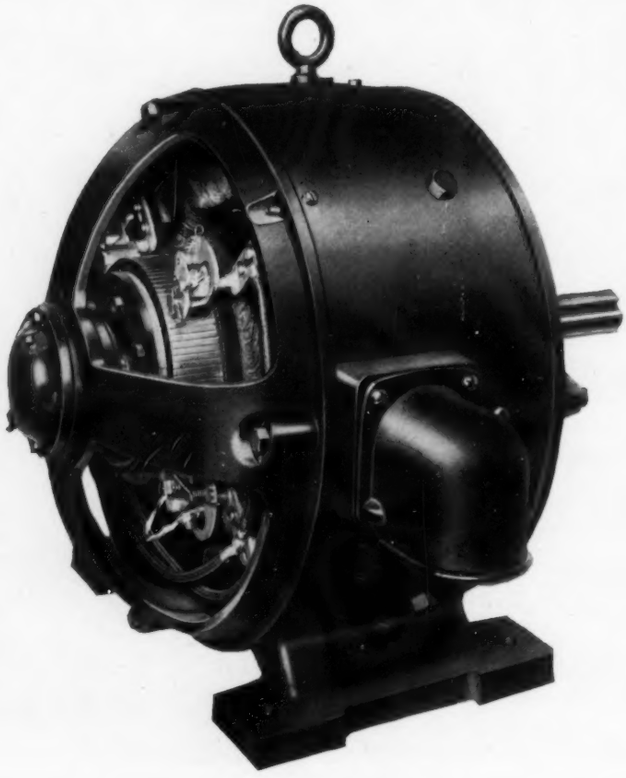


Fast's Coupling on Plate Mill, Lukens Steel Co., Coatesville, Pa.

THE modern Steel Mill practice of locating mill drive motors in dust-proof motor rooms is simplified by the use of FAST'S floating shaft type of self-aligning coupling. The floating shaft, an integral part of the coupling, is extended through the partition wall, thus simplifying this type of installation and providing dependable mechanical compensation for misalignment.

THE BARTLETT HAYWARD COMPANY . . . . . BALTIMORE, MARYLAND





THE TYPE "S" BALL BEARING AS IT IS TODAY 26 YEARS OLD

He Profits Most Who Serves the Best

We are constantly striving to serve our customers through the medium of QUALITY in our product.

To the shrewd buyer, Price is of secondary importance to QUALITY, and he knows that a saving in Price can never equal the Dependable Operation of a QUALITY product. Our Prices are in line, but our QUALITY is exceptional.

Descriptive literature sent on request.

Consult our Engineering Department at any time on your Motor Problems. There IS a motor for every application.

"QUALITY FOR HALF A CENTURY"

ELECTRO DYNAMIC COMPANY

BAYONNE, N. J.

MASTER PORTABLES

A Remarkable Line of Rugged Instruments

JEWELL

with a meter for every test

Do you use portable testing instruments?

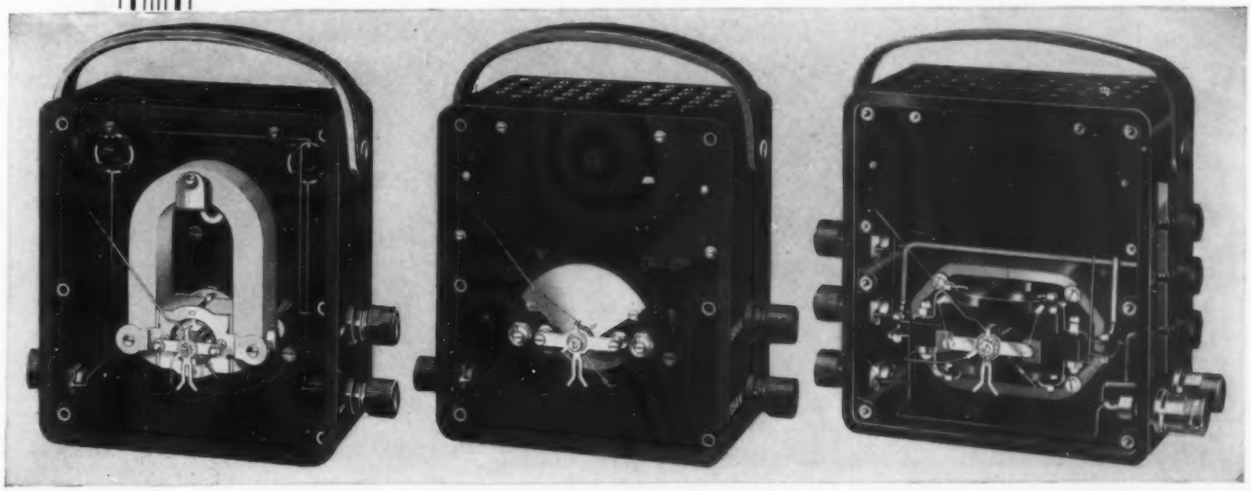
If you do, consider carefully these advantages of Jewell Master Instruments.

1. ***All instruments are furnished in bakelite cases of uniform dimensions.***
2. ***Large scale openings are enclosed with non-shatterable glass.***
3. ***Movements are famous for accuracy and ability to withstand hardships of portable testing service.***

The Master Line includes Voltmeters, Ammeters, Wattmeters, Thermal Voltmeters, and VoltAmpWattmeters for alternating and direct current. There is a meter for every test. Send for descriptive bulletin.

Jewell Electrical Instrument Co.
1650 Walnut Street Chicago, Ill.

The remarkably large scale opening, enclosed with non-shatterable glass, makes the Master Instrument easy to read.



For direct current voltmeters and ammeters, the Jewell Style G Permanent Magnet Movement is used. The mechanical assembly is rigid, assuring stability of calibration. The rapid action and high damping speeds up all test jobs.

For alternating current voltmeters and ammeters, the Jewell Style D Iron Vane Movement is used. The damping chamber is of molded bakelite and highly efficient. The iron vane is riveted to the shaft to assure a permanent assembly.

For single and polyphase wattmeters, the Jewell Style L Dynamometer Movement is used. The vane box, supporting pillars, coil supports, and covers are of molded bakelite. The magnetic shield protects the instruments against external fields.

30 YEARS MAKING GOOD INSTRUMENTS

JEWELL

MASTER INSTRUMENTS

CLEVELAND CRANES

DROP COSTS OF MATERIAL HANDLING

IT IS NOT AN ACCIDENT WITH CLEVELAND CRANES . . they are engineered to do that very thing. Due to the efficient and thorough application of roller bearings, herringbone gears which run in oil, and the high strength to weight ratio of the unit structures, Cleveland Cranes pick up quickly, roll easy and travel fast. Operation of these sturdy cranes requires less power and less maintenance. Strong and rigid with minimized friction in moving parts, Cleveland Cranes wear less under continuous operation. Thus, Cleveland Cranes are forced by their efficient design to drop the cost of material handling to a new low and keep it there.

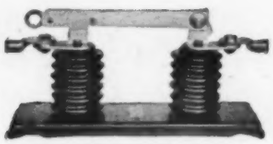
Manufacturers of CLEVELAND TRAMRAIL SYSTEMS

The Cleveland Crane & Engineering Company, Wickliffe, Ohio

50 Church Street, New York City — 512 Farmers Bank Bldg., Pittsburgh, Pa. — 4-259 General Motors Bldg., Detroit, Mich. — 559 Railway Exchange Bldg., Chicago, Ill.

CLEVELAND CRANES

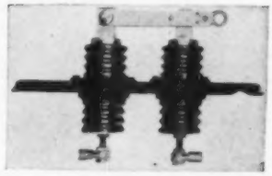
All Sizes for Every Service



Disconnecting switches embodying unusual developments.

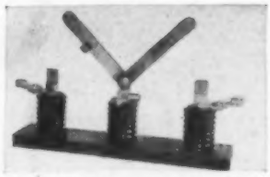
A few Elpeco Indoor Switches

for the good of the Service

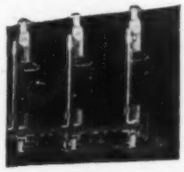


Back connected disconnecting switches with lock blade, rolled copper clips and pressed steel base.

Front connected disconnecting switches with special tube lug terminals.

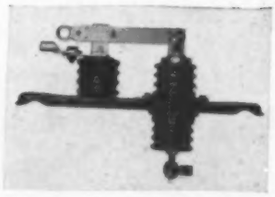


Disconnecting switches with "L" shaped blades used for group operation.



ALSO:

Porcelain base switches, single and double throw up to 6600 volts, 100, 200 and 300 amperes.



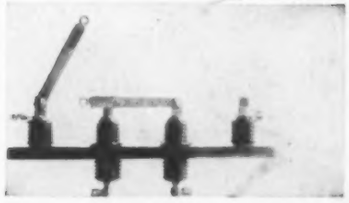
Disconnecting switches mounted on pressed steel base, hinge clip back connected, contact clip front connected with lock.

Elpeco

affords the engineer a line of indoor equipment embodying every modern improvement and many distinct Elpeco advantages.

Good engineering—Good manufacture—Good delivery.

Bulletins are available on each item.

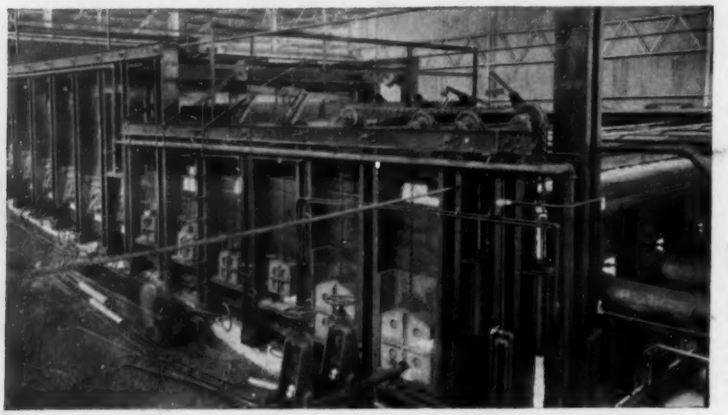


Regulator switches save space and money over single pole switches.

ELPEC

ELECTRIC POWER EQUIPMENT CORPORATION

412-420 NORTH EIGHTEENTH ST. PHILADELPHIA, PA.



94-Foot Billet Heating Furnace with Detrick Roof

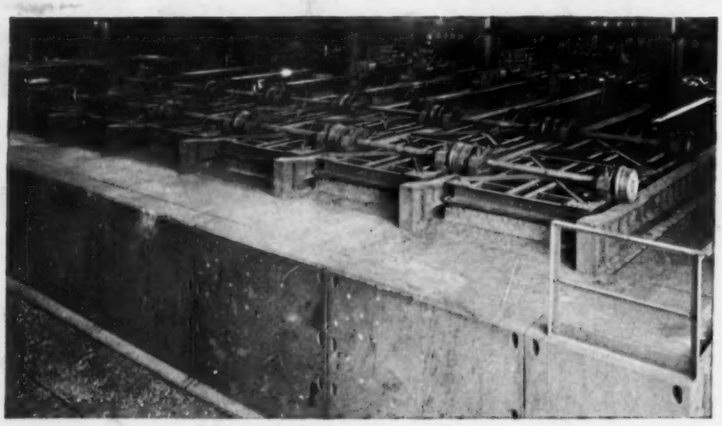
A Typical Detrick Installation . . . .

a ninety-four foot billet heating furnace in the Gambrinus plant of the Timken Company. The suspended arch principle employed by Detrick means flexibility of design, allowing for expansion and contraction of the refractory material without damage, assurance that the roof will not collapse, and makes it easy to replace burned out patches without disturbing other section of the roof.

SUSPENDED ARCHES FOR HEATING FURNACES

DETRICK

SOAKING PIT COVERS



Detrick Covers on Chapman-Stein One-Way Fired Soaking Pits with Tile Recuperator.

On the left are soaking pit covers embodying the Detrick Suspended principle which consists of center-grooved tile suspended by cast iron bars from structural steel beams spanning the pit and framed into outside structural members of the moving frame.

The use of suspended tile eliminates the possibility of cover failure due to constant jars and shocks; provides a better seal on the pit walls and makes it possible to repair the cover in small sections without disturbing other sections of the cover.

Ask Detrick Engineers — furnace experts — to study *your* furnace conditions and report what Detrick construction will do for you. No obligation!

▲

Detrick construction has reduced maintenance cost in many prominent plants (names on request.)

M. H. Detrick Co.

140 S. Dearborn St., Chicago, Ill.

Our sixty-four page catalog gives illustrations and full details concerning Detrick Arches, Walls and Roofs. Write to our nearest office for a copy.

New York: 50 Church St. Philadelphia: 1421 Chestnut St. Pittsburgh: Empire Bldg. Detroit: Penobscot Bldg. San Francisco: Russ Bldg.